STRUCTURE AND DEVELOPMENT OF POWER INDUSTRY: 1960-1985

ABSTRACT

THESIS
SUBMITTED FOR THE DEGREE OF
Doctor of Philosophy
IN
ECONOMICS

BY
SHAUKAT HASEEN

Under the Supervision of
DR. ASHOK MITTAL

DEPARTMENT OF ECONOMICS
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

1993

Power is the most important ingredient and the basic infrastructure needed for economic development of a country. It is the basic input for industrial development and economic growth of a country. This prime input has a very prominent role in agriculture, industry, transport, commercial and domestic sector of national economy. Power is the most preferred form of energy due to its versatility and convenience both in its use as well as its generation, that is why its demand and supply both have been increasing much faster, compared to other forms of energy.

The objective of the present study is to analyse overall performance of power sector in India. The objectives may be categorised under two broad headings :

(i) To evaluate overall development in power sector in India and also examine the performance of three types of power industries, namely - hydel, thermal and nuclear.

(ii) To analyse the structural changes which have taken place during the last 30 years.

The study has been divided into eight chapters. A summary of each chapter is chronologically given in the paragraphs that follows.

Power Industry in India has developed into one of the most important basic industries of our economy. Before independence there were very few and small power stations in India which were owned and operated by private as well as public establishments. In 1938 the National Planning Committee of the Congress made a number of recommendations for the growth of electric power generation and consumption. These recommendations remained the guiding force behind the power policy after independnece in India. The constituent (legislative) Assembly passed the Electricity (Supply) Act on 10th Sept. 1948 to provide for rationalisation of production and supply of electricity.

Since the short term solutions to mitigate the immediate power shortage have been getting priority over long-term solutions, consequently thermal projects having substantially shorter gestation periods have been getting pushed up for early gains, leading to the deferring of benefits from hydro schemes and power development have moved along sub-optimal course. The delays in environment and forest clearance are also responsible for slow growth of hydro power in India. Hydro power has also been delayed due to differences and disputes between States on sharing of water resources. Besides this, uncertainties in constructing civil works in difficult geological terrains and several administrative and managerial problems associated with specific hydro projects have also been contributing to the slow pace of hydro power development in the country.

Though thermal power has a maximum share in the total power generation in India as it constitutes over 67 per cent of total installed capacity and contributes over 69.8 per cent of total power generation, but its performance has not been upto the mark due to various reasons such as low plant load factor in thermal station, high percentage of unforseen outages, inferior quality of coal, unavailability of spare parts, short supply of coal, poor maintenance, outdated design of equipments etc. Plant load factor, which provides an indication of performance of thermal plants is not satisfactory in Indian thermal power stations. Plant load factor has been low due to ageing of some of the thermal plants, higher incidence of outages, poor quality and inadequate supply of coal, nonavailability of spares in stock, inadequate maintenance, indequate training of staff, defective supply of equipments etc. Some of the State Electricity Boards are operating at plant load factor as low as 30 per cent. It has also been observed that number of outages have been increasing in thermal plants. Due to excessive outages full generating capacity is not utilized in thermal power plants.

India is producing only 2 per cent of electric power from nuclear sources, but radiation hazards and safety aspects associated with nuclear power plants create problems in installing a new nuclear power plant. Safety of reactors is one of the main factors restricting the expansion of nuclear power.

The structure of power industry in India has emerged over a period of nearly hundred years. At the beginning of the twentieth century a few private companies were operating small power stations mainly catering to urban loads. In 1910 the Indian Electricity Act was passed to govern the grant of licenses for electricity generation and distribution. This Act of 1910 was more concerned with the regulatory and safety aspects of electricity than with organisational structure of the industry itself. The organisational structure of power industry has emerged only after the Electricity (supply) Act, 1948 was passed. After Independence the Constitution of India put electricity in the concurrent list and it became possible for both the Union Government and

State Governments to legislate on the subject. The Electricity Act of 1948 laid down that a sound, adequate and uniform national policy should be developed coordinating the activities of planning agencies in relation to control and utilization of national power resources. It was in accordance with this Act that outonomous Electricity Boards were set up in all the eighteen states except in some north-east areas and the Union territories. These boards were entrusted with the responsibilities of promoting the cordinated development of generation, transmission and distribution of electricity within the state in the most efficient and economical manner. State Electricity Boards play a major role in our country's power policy. The power supply industry is presently owned and operated by and large by the State Electricity Boards. The Electricity (supply) Act, 1948 also envisaged creation of Central Electricity Authority under the Central Government with the responsibility to develop a sound, adequate and uniform national power policy and Co-ordinate the activities of the various planning agencies.

In 1976 the Electricity (Supply) Act, 1948 was amended to provide for establishment of generation companies under the authority of central Government. The national company namely National Thermal Power Corporation (NTPC) and National Hydro Power Corporation (NHPC). The NTPC was given the authority to establish regional thermal power Stations and made responsible for bulk transmission from these units to the state power system. The NHPC was established to set up major hydro electric projects on regional and national considerations. The Department of power was created in 1974 by the Ministry of Energy. The Department of power is responsible to parliament for laying down national policy planning for the development and regulation of the power resources in India.

Inspite of heavy investment made by the Government and sizeable expansion taken in electrification of villages, most of the villages experience power cut or irregular supply of power specially during the peak period. Regular supply of power is essential for overall economic development of rural areas. It has also been observed that rural electrification has mainly benefitted large and medium farmers while small farmers are not getting full benefit of it due to inadequate credit facilities.

Many structural changes have taken place in the power sector in India since the beginning of this century. After independence the Government of India and State governments have established a number of corporations and boards to develop power industry efficiently. But we have observed that these corporations and boards have failed to achieve the desired objectives. It may be due to large bureaucratisation and red tapism. Another significant point that we have observed is the lack of co-ordination between these bodies.

It has been observed in the study that the gap between demand and supply of power has been increasing at a faster rate. In the context of the present power shortage and resource crunch for implementation of new power projects, various measures to manage the supply and demand may help in bridging the existing gap.

The first measure to improve the supply is to get better output from the existing facilities. To increase the supply in a situationof resource constraints optimal output from existing installed capacity is needed. To achieve these, the power generating units which were installed more than a decade back and were based on the outdated technology prevalent at that time, may be made to give better output by utilising the advanced technology available in the field through modification and renovation of the equipments.

The demand management consists of shifting system load from peak hours to the off peak and thereby improving to power system load factor.

It has been observed in the study that transmission and distribution loss is high in the sector in India. The growth of transmission and distribution system could not keep pace with the growth in generation capacity may be due to low level of investment in transmission and distribution during the five year plans. This has resulted in several imbalances in the system performance. Therefore, it is proposed that due priority may be given in making adequate investments in transmission and distribution works with a view to reduce the imbalances.

Analysis of hydro power development depicts that hydro power development was given high priority during the first three five year plans. It registered substantial increase during these plans. The decline in the contribution of hydro power to the overall capacity addition commenced in the Fourth Five Year Plan, reached a value of 28 per cent at the end of the Seventh Plan. An optimal hydro thermal mix for improved economies of system operation indicates a ratio of 40:60 for the Indian system. Therefore, it is suggested that necessary measures should be taken to improve the hydro-thermal mix during the course of planning.

It has observed in the study that 66226 MW of potential available for hydro power development still remains unharnessed despite inherent advantages of hydro electric power plants over thermal and nuclear plants. Bulk of the undeveloped potential lies in the northern region. Therefore, it is suggested that unharnessed hydro projects should be developed in those areas which are away from coal resources like Northern Region. The share of hydro power is also declining as environmental and forest clearances are given after a lapse of considerable time which has resulted in substantial time and cost over-runs. To reduce time and cost over-run due to delayed environment and forest clearance procedures, procedural bottlenecks must be identified and clearance process must be streamlined.

Acceleraed hydro power development would be the corner stone of improvement in productivity of power sector in the long-run. It has been observed from the study that performance of thermal plants in the country is not satisfactory as plant laod factor is not upto the mark. The plant load factor of thermal power plants can be improved by reducing the periods for planned shut-down of the unit for thorough maintenance work through proper organisation and coordination. Further improvement in the performance of the thermal power stations may also take place by maintaining high efficiency of operation and high degree of availability of the units. For increasing efficiency of operation of units it may be necessary that the units operate at or near the designed maximum output. Adequate maintenance and operational standards may also be of great importance for obtaining best efficiency.

To improve the performance of thermal plants, the availability of the plants should be increased. Improvement in the design of boilers, modifications in basic design and material of the equipments may improve the availability of the plant. The availability factor would also increase if forcedoutages may be brought down to the minimum by following proper maintenance practices. It has also been noticed that some of the thermal units would complete their expected life by 1994-95, while many units of 60 MW have completed their lives and majority of the 100 to 150 MW units have been in service for more than 15 years. So they require major overhauling. As the units go on ageing, their performance declines. Therefore, thermal power plants need major renovation and modernisation schemes. It is also suggested that whenever the plants under go renovation, efforts should be made to introduce modern sub-systems which were not available earlier at the time of installation of the units, to improve their performance.

It has also been observed that inferior grades of coal are being supplied to the thermal power plants creating serious problems to boilers, which were basically designed to use different and superior grade of coal. The supply of coal to power stations should be in requisite quantity and also of good calorific value according to the boiler design so that the cost of power generation may not increase further.

Air pollution is one of the grey areas with coal based power generation. The main air pollutants generated are particulate matters, sulphur dioxide, oxides of carbon and nitrogen. The improved design of electrostatic precipitators may result in controlling fly ash emission to very low level. Besides various new technologies available may also help in controlling environmental pollution of thermal plants. In view of the abundant availability of nuclear fuels in the country, it would be worthwhile to lay stress on the installation of nuclear power stations in future, specially in the areas which are far away from coal belts so as to cut down on transportation cost of coal and ease congestion on railways. However, appropriate safety measures in regard to setting up of nuclear power stations may have to be strictly followed.

It has been observed in the study that supply of power is not regular in rural areas due to lack of close integration in many states between the planning of rural electrification and the rest of the distribution network. Therefore, transmission and distribution planning should comprise the rural electrification system also, and power cut should be brought to minimum to enhance the agricultural productivity. It has also been observed that rural electrification has been uneven among the states and Union territories. For the balanced development of the rural areas backward and undeveloped states and Union territories should also be electrified.

It has also been observed that State Electricity Boards are mainly responsible for generation, transmission and distribution of power in the country, yet their performance is very dismal. They are critisized for their inability to operate power generating and distribution systems efficiently. The causes of inefficiencies in SEBs may be because the Boards have not yet adopted the modern management system. The same old bureaucratic style of functioning still prevails in the State Electricity Boards. Therefore, it is suggested that modern management system should be introduced in SEBs. Maintenance should be improved through skilled personnel and importance should be given to proper training facilities. It is also suggested that for the healthy growth of the power sector and to formulate agreed policies and programmes, there should be close and constant interaction and better coordination among different organisations of power industry.

STRUCTURE AND DEVELOPMENT OF POWER INDUSTRY: 1960-1985

THESIS

SUBMITTED FOR THE DEGREE OF

Doctor of Philosophy

IN

ECONOMICS

BY

SHAUKAT HASEEN

Under the Supervision of

DR. ASHOK MITTAL

DEPARTMENT OF ECONOMICS
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

1993

DEPARTMENT OF ECONOMICS

ALIGARH MUSLIM UNIVERSITY
ALIGARH-202002 (INDIA)

Ref. No..............

Dated...Dec. 27th, 1993.......

TO WHOM IT MAY CONCERN

This is to certify that the thesis entitled "Structure and Development of Power Industry:1960-1985" is the original work of **Ms. Shaukat Haseen** under my supervision and is suitable for submission for the award of Ph.D. degree in Economics.

Ashok Mittal

ASHOK MITTAL
Reader

CONTENTS

A C K N O W L E D G E M E N T S

I am obliged to express my deepest sense of gratitude to **DR. ASHOK MITTAL** under whose guidance I have been able to complete my research work. His supervision and counsel have proved invaluable to me. His constant support, encouragement and inspiration have helped me to complete my work successfully and for that I shall remain greatly indebted to him.

I would like to thank sincerely **Professor A.Z. Rizvi** Chairman, Department of Economics, A.M.U., Aligarh, for providing the necessary facilities required to carry on my work and also for extending his inestimable suggestions which have proved to be of great help during the course of my work.

My profound appreciation also goes to **Professor (Mrs.) K.S. Khan** for her precious suggestions and constant encouragement which is of great significance to my work.

I record my indebtedness to **Professor S.K. Singh** (Indira Gandhi National Open University, New Delhi) for his suggestions and excellent co-operation and assistance.

I am grateful to all my teachers in the Department of Economics, A.M.U., Aligarh, and all my friends who helped and co-operated with me.

I am also thankful to **Mr. Krishan Swaroop Aggarwal**, Chairman, Central Electricity Authority, New Delhi for his kind help.

The continuous assistance I have recieved from librarians and staff of various libraries and institutions can not go unapplauded. For their help, I would like to acknowledge the Ministry of Energy, New Delhi. Central Electricity Authority, New Delhi. Department of Economics A.M.U., Aligarh Maulana Azad Library A.M.U. Institute of Economic Growth, New Delhi and Tata Energy Research Institute, New Delhi.

Last but not the least, I owe greatly to my parents for helping me to keep up my spirits. Their encouragement has helped me to boost my efforts. I truly feel that without their help my endeavours could not have been successful.

My thanks are also due to **Mr. Afsar Faizan** who has taken pains in typing the thesis efficiently and correctly.

I shall be honoured and greatly pleased if the above mentioned accept my appreciation and gratitude.

Shaukat Haseen

(SHAUKAT HASEEN)

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

CHAPTER - I

INTRODUCTION

Power is the most important ingredient and the basic infrastructure needed for economic development of a country. It is one of the powerful vehicle of economic progress and social changes. It is the basic input for industrial development and economic growth of a country. This prime input has a very prominent role in agriculture, industry, transport, commercial and domestic sector of the national economy.

"The availability of easily transportable and cheap energy transformed the face of western world through wide-spread industrialisation, generation of new employment and consequent urbanisation, modernisation of agriculture, increase in social and civic amenities for community etc. Indeed, electricity delinked the working of human mind from primeval and tribal attitudes to one of enlightened vision" (Kumar, R., 1986).

In this chapter an attempt has been made to explain the problem, scope, objectives and limitations of the present study. The data base, methodology,, plan of the study and review of the available relevant literature have also been underlined in brief.

1.1 PROBLEMS OF THE STUDY

Electricity is an important intermediate input in the production of various commodities. It is mainly produced in the public sector in India with three types of sources, namely, hydel, thermal, and nuclear. It is mainly consumed by industrial, agricultural, and domestic sector of the economy.

The main problem of power sector in India is the gap between consumption and supply of power, which is continuously increassing. The rapid development of industries, speedy rural electrifiction, expanded irrigation facilities and change in the socio-economic life of people have increased the consumption of power. As a result, rate of growth in demand of power has outstripped the rate of growth in the installed generation capacity. Besides, there is also a gap between installed capacity and actual generation of power due to very low efficiency levels in power-stations in India. The availability of electric power from already installed capacity has not been upto the mark.

Structural shifts are taking place in generation of power from hydel to thermal and from thermal to nuclear. A shift is also taking place from supply side, as supply of electric power has been shifting from urban areas to rural centres.

To manage the production and transmission of power, administrative responsibilities have shifted and some new bodies have come up. The Government of India has made certain structural changes in the Electricity (Supply) Act, 1948 during the Fifth Five Year Plan to increase the share of Central Government in the generation of power. As a result National Thermal Power Corporation and National Hydro Power Corporation were incorporated in 1975 under the Central Sector. Different types of power generating plants have their own problems. Though hydro power is clean, renewable and has low operational cost, yet its share in total installed capacity has declined in India.

Nuclear power has some economic advantages over other forms of generating electricity. Environmental pollution casued by nuclear plant is minimum but there is always possibility of catastrophic nuclear accidents, which is a matter of great concern from the point of view of safety.

The thermal power plants constitute the backbone of power scenario in India, as they contribute the highest share in the total production of elecricity and hence, are very important for the economy. But it is being generally observed that the thermal power plants are generating electricity much less than their installed capacity.

plant load factor in thermal plants has been very low. Forced outages have been increasing due to which full generating capacity has not been utilized. Thermal plants in India also face the problem of low quality and inadequate supply of coal. Supply of coal is irregular and inadequate to thermal plants. Sometime low grade coal and sub-standard quality of coal is supplied to them resulting in serious damages to the equipments.

In brief, the performance of power sector is not satisfactory and there is a need to examine it in detail.

1.2 OBJECTIVES AND SCOPE OF THE STUDY

The objective of the present study is to analyse overall performance of power sector in India. The objectives may be categorised under two broad headings:

(i) To evaluate overall development in power sector in India and also examine the performance of three types of power industries, namely - hydel, thermal, and nuclear;

(ii) To analyse the structural changes which have taken place during the last 30 years.

We have tried to analyse the power sector from 1960 to 1991 to cover the lasted development in this sector, although the title of the thesis refers till 1985 only.

1.3 DATA BASE AND METHODOLOGY

Data source of this study is mainly secondary, obtained from various government reports and publications.

We have tried to make uniform source of the available data as far as possible.

Keeping the aforesaid objectives in mind, the entire work of the study is carried out into three parts. In the first part of the study, a detailed survey of the available existing published literature has been undertaken, with a view to get acquainted with the power sector. In the second phase of the study, the relevant data and information about the growth of power sector is made use of and the performance of the three power generating industries has been analysed. In the third phase of the study structural changes have been examined.

The data have been systematically arranged and synthesised for arriving at certain conclusions regarding the development and structure of power industry in India.

1.4 DEFINITION OF THE TERMS USED

WATTS

Watt is the unit of electrical power or the rate at which electricity is being produced and used. One thousand watts is known as kilowatt (KW). A kilowatt hour (Kwh) is the unit of electrical energy and is equal to 1,000 watts hour.

PLANT LOAD FACTOR

Plant load factor (PLF) provides a measure of average performance of thermal power plant and is defined as:

$$PLF = \frac{\text{No. of Kwh generation during a year}}{\text{Installed capacity x 8760}} x100$$

The numerical figure in the denominator is obtained by multiplying the number of days in a year with number of hours in a day.

INSTALLED CAPACITY

The installed capacity of the power system is the sum of ratings of maximum continuous kilowatt capacity in the system during a year.

PEAK AVAILABILITY

Peak availability of a power system is the maximum power available to the system at the power station bus bars at the time of peak load during a year.

PEAK LOAD

Peak load is the maximum simultaneous ultimate customer demand within the supply area of the power system which occurs during a year as measured by actual deliveries at generating station bus and bulk sources.

OUTAGES

Outages represent the complete close down of the unit in a year. Outages are of two kinds, i.e., forced outages and planned outages. Both of them are measured separately.

FORCED OUTAGES

Forced outages are those when a unit is closed down due to technical and unforseen causes.

PLANNED OUTAGES

Planned outages represent shut down of a unit for scheduled maintenance and overhauling.

1.5 LIMITATIONS

The generation of electricity is a highly technical and engineering problem. On the basis of plant load factor a rough estimation may be made about the performance of the power plants.

Due to the difficulties in procurring data related to the cost of production, the extent of pollution and pollution controlling devices, we could not analyse the cost structure of various types of power plants and environmental problems related with the power industry. We have not discussed the pricing of electricity as it is out of the scope of the study. On account of time constraint, the working of various government bodies have not been analysed in detail.

1.6 PLAN OF THE STUDY

The present study is divided into eight chapters.

In the first chapter, an attempt has been made to outline the problems, objectives, scope, limitations, data base and methodology of the entire research work. The definitions of various terms used in the study and review of the available relevant literature related to power sector are also included.

The second chapter deals with the growth of power sector in India. Sectorwise power consumption in India has been briefly discussed. It also highlights the development of power during various five year plans. Investment on power sector and the development of transmission and distrubituion networks have also been elaborately analysed.

The third chapter examines the progress of hydro power generation in India. It outlines total hydro power potential available in the country. The chapter also reviews the present position of hydro power generation and also focusses upon the problems related to slow growth of hydro power generation in the country.

In the fourth chapter growth of thermal power in India has been dealt. It examines the installed capacity, thermal power generation, plant load factor of different unit sizes, state-wise plant load factors and plant load factors in National Thermal Power Corporation units. Performance of the thermal power plants, reasons of outages, and modernisation schemes have also been examined. An attempt has also been made to highlight the problems related to the operation of thermal power plants in India.

The fifth chapter has been devoted to deal with the development of nuclear power. The economics of nuclear power generation has been discussed in brief. An assessment of uranium reserves in India has been made. The nuclear power development in India has also been reviewed.

The sixth chapter highlights the structure of power sector in India since its inception. It also analyses the structural changes that have taken place in the power sector for the last three decades.

In the seventh chapter the growth of rural electrification in India has been given. An analysis of investment on rural electrification has been made. It also focusses on Rural Electrification Corporation which forms the basis of growth and expansion of electricity in rural areas. The time profile of rural electrification and energisation of pumpsets has also been studied.

The eigth chapter concludes the findings of the preceding chapters. Alongwith the conclusion, a few suggestions have also been made for bridging the gap between demand and supply of power and improving the performance of thermal and hydro plants and increasing the availability of power from the existing installed capacity.

1.7 REVIEW OF THE LITERATURE

In this section we have tried to study the existing literature available on power sector. Individual studies made on different aspects of power sector we have also been included.

Venkatraman (1972) highlights various aspects of power industry such as financial, organisational, electricity tariff, financial working of elecricity boards, rural electrification, union and state relations in power development. Industrial growth depends on the supply of power in adequate quantity and available at the requisite periods of time and at a reasonable rates.

The power generation, transmission and distribution constitute an important public sector industry. The lion's share of power generation in India is handled by the electricity boards established by various states. The author has also analysed finances of the State Electiricity Boards. The main findings of the study are that there is a situation of imbalances in the financial structure of the electricity undertakings which dates from the days when they were seen departmentally. A comprehensive analysis of the financial aspects of State Electricity Boards to identify the basic casuses for financial disequilibrium prevailing in electricity utilities has been made. For this, relevant data has been arranged and presented very carefully. He describes that if the financial scarcity of the State Electricity Boards had recognised earlier, it would not have been difficult for creating a sound financial system of the State Electiricity Boards. The state's finances in India have tended to exhibit a fundamental disequilibrium arising out of the distribution of power and financial resources in the constitution. Power development has been a major recipient of the capital assistance given by the Centre. State receive the Central assistance in the form of loans. The problem of repayment of these loans by States is a major one, because States pass on the loans to the electricity boards and they themselves have to make arrangements for the repayment. Power financing in India has therefore a major dimension in the shape of Centre-State relations but this is an aspect which has not been studied and investigated sufficiently so far.

Chetty (1976) discusses the role of operation and maintenance in power su.,pply industry. Proper practices and timely schedule of maintenance of equipments and line play a crucial role for a reliable power supply.

During the process of operation, certain natural deteriorations take place in machines, plants or equipments which result in a loss of captial or increase in operational costs. Certain processes have to be performed on each kind of plant and equipment to nullify and counteract the deteriorating factors so as to keep the plant and equipments in fully efficient condition for satisfactory and economical operation and these processes are called 'maintenance'. Operation and maintenance of system go hand in hand. Proper understanding of operational procedure will minimise the maintenance process and saves maintenance costs and results in increased revenue. A systematic maintenance schedule helps in greater operational reliability.

Efficient functioning of an electricity distribution requires reliability of power supply, satisfactory volatage, low line losses, optimum power factor and minimum theft of energy.

Govil (1978) has made an attempt to take a look at the reasons of haphazard management and development of power sector. There has been a shortfall in the planned addition in installed capacity of 200 MW in the First Five Year Plan, shortfall of 1200 MW during Second Five Year Plan and 2520 MW during the Third Plan. Reasons for these shortfalls have been studied in this paper. The main cause of delay in power development were due to lack of adequate project data and investigations before finalising technical project report, delay in issue of authorisation by Central or State authorities, deficiency in organisation for planning and engineering the project, delay in procurement and delivery of the equipments, change in top personnel in the course of implementation of project, shortage of cement and steel etc.

Pachauri (1978) throws light on economic issues in planning for electric power in India. Problems in the power sector of the Indian economy have atttracted greater attention at official as well as non official levels. Since the demand for power is a derived demand, and consumption of electricity takes place in a range of domestic, industrial, agricultural and commercial activities, therefore, interruptions in supply bring about a halt in all these sectors, and thus any lapse in power supply receives immediate attention.

The importance of various concepts and issues related to planning in the power sector, which have not receiveed sufficient attention from decision takers and ploicy makes bodies in the country, are discussed in this paper. Any exercise in planning in this sector must essentially deal with planning for the economic system as a whole.

Gupta (1976) examined rationalisation of production and supply of electricity and measures conducive to electritcal power development. Indian constitution enlists electricity in the concurrent list and places authority on the State Government to amend the Central act. The Central act is generally flexible from the point of view of management of the boards including their business.

The author is of the view that the bright business prospects in the case of electricity ensures earning a surplus, provided the appropriate scientific business management is introduced.

For scientific business management of power supply undertakings the study suggests following items - Devising of systems of coordination with different wings of the Central and State Government agencies for effective utilization of capital and early return with overall perspective on national economical considerations. Introduction of the use of computers as an aid to management, employment of managerial/supervisory personnel accroding to the qualifications, experience for the job requirement, Introduction of refresher course and training facility for all categories of personnel at regular intervals and special incentive on area basis for effective utilization of plant and machinery per KW or KVA installed.

Hans (1972) describes that inspite of large number of options available to India in the energy group, power seems to be the best bridge that can help the country tide over the crisis. It can play an important role in the development process of the country. But its role cannot be measured exclusively through economic terms such as GNP alone. Keeping in perspective global changes and a new awareness of man and his relationship with society. States today include social indicators as well. Power industry comprising of so many areas of life, is no longer an economic or technological area of study, but has become a human problem. It has social effects and therefore, constitutes one of the problems facing the identity of a nation. The socio-political-economic impact of power has therefore, to be studied on a vast canvas in which planning plays a significant role. She has also analysed the progress of power during the five years plans.

The study reveals that planning in power sector was not accurate. The gap between demand and supply kept on increasing with time and growth rate projections in the power sector turned out to be completely out of touch with reality of the situation. A policy to increase both agricutlture and industry without any relation to the power sector has meant that ultimately both industrial growth and, economic growth as a whole have suffered.

For future power policy, emphasis is being laid on the use of advanced technology in power sector and self reliance in production. A national policy linking together all the regions essential for the balanced growth of power industry.

There is a considerable scope for energy conservation in both the industrial and agricultural sectors in India. Conservation, therefore, should become a crucial principle of governmental policy. Research and Development Insitutes need to be set up by the Government to devise power saving devices for the use in industrial sector.

The study suggets that there should be a uniform national tariff policy. Determination of tariff rates is erratic and based on political rather than on economic factors. A national tariff policy is essential to make the sector work in cohesive manner. A single tariff policy will help in the integration of this sector physically and avoid regionalism.

Jain (1984) outlines present status of integration of power systems in the country with the ultimate objective of realising a national power grid and tried to identify the factors that are coming in the way of smooth integrated operation. These include sustained under - frequecy and over - frequency operations, improper load management and unscheduled drawals of power, large voltage excursions, inadequate monitoring and controlling facilities and lack of incentives in commercial agreements. The study suggests some measures to overcome these problems. These include joint conceptualisation of an operation and control philosophy, agreement to operate the interconnected systems at a single declared frequency within a narrow band and load management scheme, provision of under frequency relays, metering and instrumentation facilities, adoption of an integrated approach in setting up load despatch centres, establishement of a well knit communication system owned by the power utilities, proper commercial agreements for inter-state exchanges.

Puttaswamy (1984) describes briefly present day prorblems connected with the power systems in India, in general and deficiencies in planning and efficient operation of interconnected power system in particular. The author describes that the first and foremost problem faced by the power systems is inadequate generation capcity due to inadequate funds, slippages in project schedules, low run-off, deficiency in the utilisation of full installed capacity and inter-state disputes.

A fundamental change in the financing policy is necessary to provide adequate resources for power projects, transmission and distribution system. Long term (say 15 to 20 years period) power planning and concurrent power, system studies are essential features for developing a well planned national power grid for India. Introduction of rule/regulations/contracts to enforce decisions taken to achieve fast and efficient operation of interconnected power systems is very necessary. Manpower development and training is of utmost importance to maintain and operate power systems efficiently.

Sambamurti (1984) outlines the historical background of power in India. Power development has been given a very high priority in the plan programmes. The central purpose of power development has been to extend power supply to all parts of the country and provide supply of power of appropriate quality at the lowest possible cost.

Power development in India is mainly based on hydro and coal resources. During the first fifteen years of planned development emphasis was placed on hydro power as a part of the multi-purpose development of river valleys. In the subsequent period attention was focussed on thermal power development to accelerate growth.

Technical factors governing hydro,thermal and nuclear power are also discussed. The author also highlights problems of investments in power sector, which have accentuated due to steep esclation in cost of inputs and other equipments in recent years.

Verma (1985) analyses cost of electricity generation in State Electricity Boards in India. Power industry is based on the principle of "operating costing" which is concerned with ascertaining the cost of electricity generated, transmitted and distributed. The unit of cost in power industry for presenting production cost data is 'kilowatt - hour' (Kwh). The total production is divided by the number of units generated during the period and presented as cost in paise per unit.

The cost structure in State Electricity Boards in India includes generation cost, transmission cost, miscellaneous cost. The study presents the generation cost of six State Electricity Boards including Gujarat, Haryana, Madhya Pradesh, Orissa, Punjab and Rajasthan.

The data on generation cost of all the six State Electricity Borads shows an increasing trend through-out the period of study.

Keshava (1986) highlights some aspects of the theory of electricity pricing relevant to developing countries including Traditional Approach of Electricity Pricing, Marginal cost pricing, Short-run and long-run Marginal costs and peak load pricing. Electricity supply undertakings produce a commodity essential to daily life, they are natural monopolies largely because of technical indivisibilities and they have fiscal and welfare objectives. The fiscal and welfare objectives of public utilities, have several implications for pricing. While the fiscal objective is related to fair returns on capital invested, the welfare objective is related to the maximisation of utility from the output for the benefit of society.

Author has also made an attempt to relate the theoretical discussion to the recent developments in France, United Kingdom, United States of America to illustrate the issues involved and further to draw appropriate lessons for electricity pricing in developing countries.

Bami (1987) throws some light on the power development in India during the five year plans. The remarkable increase in economic infrastructure facilities in the country is due to heavy investment in power sector during the planning period. But inspite of heavy investment and emphasis on power sector during the planning period, the supply has fallen short of demand due to non-availability of power. This affects the industrial sector, agricultural growth and other sectors of the economy adversely. He therefore, suggests scientific and comprehensive planning for reducing the gap between demand and supply.

Chand (1987) highlights power development during the Seventh Plan and power programme for the Eigth Plan. The capacity addition of about 35, 000 to 38,000 MW during the Eighth Plan would enable the country to meet, by and large, the electric power demands. There would, however, be shortages to meet the peaking demands as creation of additional generation and associated transmission facilities of the required extent has to be contained mainly due to constraints of financial resources.

Inspite of the achievement made so far for power development, the country faces acute power shortage. This is on account of the fact that the developing countries often face the dilemma of having an electric power growth rate much higher than Gross Domestic Product, on one hand, and constraint in resources on the other. The problem gets further aggravated due to the fact that the investments required to finance the power development programme keep on increasing considerably both on account of the growing size of the power programme and escalating capital intensity. It is in this context that the challenges that face the power industry need to be reviewed.

Desai (1987) outlines some of the forces that shaped the growth of power system in India and assessed the efficiency of the system. The author has examined the demand for power which has increased rapidly in agricultural and industrial sector after independence. The resources of electricity are also discussed. Electricity is mainly generated from hydro and thermal resources in India. The development of hydro electricity is slow due to long construction period and political problems, with the result 60 per cent power is generated from coal. The author has also discussed investment and finance in power sector.

Chand (1988) describes in his paper that the country has made rapid and significant progress in power sector since independence. The installed power capacity and generation has been increasing with the increase in demand and consumption of power. The demand of power has outstriped the supply of power as its consumption has increased enormously in various sectors of the economy. Electric power is the main input for economic development its consumption is increasing with the advancement of the country. The author suggests that the power generation should increase to bridge the gap between demand and supply.

Rajgopal (1988) examines power scenario in India. The installed generating capacity which was only 2300 MW in 1950 increased to 58,000 MW in 1989. There has been an increase in the power generation from 5 billion units in 1950 to 221 billion units during 1988-89. The per capita power consumption has increased from 0.5 units to 200 units in the country.

The planning and the operation of the power sector is a very complicated subject which needs long-term planning, co-operation between Centre and State governments, between Central Electricity Authority, Central Sector power generation companies and State Electricity Boards and the management of various inter-related functions like generation, transmission distribution as well as conflicting political and social requirements of a large coutnry like India. This is one sector which fulfills the basic need for various development activities of the country, viz. agriculture, industrial, commercial, rural as well as urban.

Survey (1988) examined the development policies and problems of the Indian power plant sector. The author finds that electricity supply is highly capital intensive. The State Electricity Boards own the major part, around 81 per cent of electricity supply. Remaining 5-6 per cent is owned & Operated by National Thermal Power Corporation, 5-6 per cent is owned jointly by State Electricity Boards and Central Government. Also another 2-3 per cent is controlled by the Department of Atomic Energy. In this study main emphasis is being laid on Bhart Heavy Electrical Limited (BHEL) a public enterprise, manufacturing power equipments. The financial performance of BHEL and industrial material and components supplied to BHEL has also been examined. The author also throws light on production capacity and size of BHEL market which is continuously increasing. The main challenge for the future is to achieve higher productivity of the capital employed in this sector by strengthening indigenous technological capabilities in all aspects of power engineering.

Bhasin (1989) focusses on the development of power sector in India since independence and its contribution in socio-economic development of the country. He has focussed on various issues relating to the power sector, measures which should be adopted to achieve the targetted growth rates and emerging power scenario at the end of nineties. The issues involved and adoption of suitable measures are important for power development of long-term basis.

Narayan (1989) highlights power problems and some of the prospects of power development in the Indian context.

Power was given significant importance in the plan programme and progress of power has been impressive during the plan period. But hydro - thermal mix has been going down in every successive plan.

The study suggests long-term strategy for proper power development in the country including acceleration of hydro development by focussing attention on removing various inadequacies in the areas of organisation, management and funding, adoption of coal benefication through sophisticated techniques which would ensure better quality of coal to the power plants, taking up of larger programme of transmission and distribution to remove the present inadequacies, strengthening of the regional grids and bringing about an improvement in the power system operation to reduce the transmission and distribution losses.

Renovation and modernisation of hydro and thermal plants are stressed for increasing generation, keeping in view the highly captial intensive nature of power supply industry, it is difficult to find adequate financial resources for implementation of additional generation capacity.

Natraj (1989) focusses on hydel and thermal power development in the country. He also throws light on power shortages which have been increasing. He has suggested shrot-term and medium term measures for increase in power availability. These measures would reduce power shortage in the country and improve the quality of electricity with some degree of reliability.

Rajgopal (1989a) outlines the thrust areas in the Eighth Plan in which the author explains the significance of power and termendous potentiality for growth in the country. Power has always been given priority in the planning process as it is clear from the plan outlays. The recent discovery of gas and the construction of gas based projects will facilitate in bridging the gap in case of short supply from hydro and coal based projects. The Eighth Five year plan emphasises on generation planning, laod management, institutional arrangements, captive power generation, reduction in transmission and distribution losses, energy conservation, research and development, financial health of State Electricity Boards etc.

Rajgopal (1989b) throws some light on the achievements of power sector in the country. The power generation has increased tremendously since independence, as enormous resources have been earmarked for power development in India. But inspite of tremendous increase in power generation capcity the supply falls short of demand. The author has also focussed on the projections of power availability during the Eighth and Ninth Five Year Plans. With the projected power supply and demand scenario the power sector will be unable to cope with the increasing needs of consumers even if capacity targets are fully achieved. For rapid power development on the most optimal path every possible resource should be utilised fully.

Suri (1989) highlights on the uniform tariff policy for central power generating agencies viz. National Thermal Power Corporation and National Hydro Power Corporation. These central power generating agencies sell power to various State Electricity Boards at different rates. The rates vary from region to region, which creates problems in maintaining common accounts all over the country. The author suggests that National Thermal Power Corporation and National Hydro Power Corporation should have uniform tariff at their power stations. For uniform tariff policy the proposed National Grid Authority should be entrusted with the responsibility of framing the commercial policies for the sale of power.

Krishna (1990) highlights the power development programme during the Eighth Five year Plan period. Due to short supply of power on account of inefficient management of power stations, the private sector has been asked to participate in the generation of power and balanced power development in the country. The author has suggested that there should be quick implementation of awaited and new power projects to increase the power supply in the country. This will facilitate availability of power at every stage for consumption purposes in different parts of the country.

Laxmi (1990) has highlighted power failure in many states of the country and its effect on social welfare. Financial resources have been diverted from other developmental areas in the hope that power will speed up progress, but this substantial investment was considered inadequate for balanced power development of the country due to lack of planning. The author has suggested various measures to manage the demand for power in the country. There should be an improvement in the performance of the thermal power stations to increase the availability of power. There should also be an effective control of peak loads management which is very important from demand side management.

Naidu (1990) focusses on potential areas for improvement in productivity and efficiency of power sector. The main problem of power sector has been the gap between demand and supply. According to the author, optimum utilization of existing available capacity is the most effective course of improving power supply position in the country. Impromvement in operation and maintenance of hydro plants and of thermal plants would reduce the power shortage. The existing capacity can be fully utilised, by taking positive steps in renovation and modernisation of thermal plants, reduction in transmission and distribution losses, optimum load management and reduction in auxiliary consumption. There should also be proper hydro-thermal mix in power sector. Hydro thermal mix in India has been going down. At present it is as low as 29:71. A minimum of 40 per cent hydro is considered to be a desireable feature. Hydro plants play very distinct role in power system operations. A respectable share of hydro eliminates backing down of thermal plants and improves their efficiency.

Nigam (1983) highlights hydro power scenario in Uttar Pradesh. The total estimated hydro potential in Uttar Pradesh is 13000 MW, out of which 1200 MW has been commissioned so far. Thus a very low percentage of 9 per cent has been utilised so far.

In Uttar Pradesh percentage of hydro installation was about 52 per cent of the total capacity in 1968. There has been a decreasing tendency during 1966 to 1969 which remained constant upto 1978 at 36 per cent. The pace of hydro-electric development has slowed down after 1960. The most important reason is said to be the constraint of financial resources which necessitated taking up of a large thermal power programme for deriving benefits earlier to meet the rapid demand for power.

For hydro power development in the state, the author suggests that having utilised only 9 per cent of the hydro potential in the state, it is necessary to accelerate hydro-power development by establishing an organisation entirely devoted to hydro-power and multi-purpose projects and having separate allocations for hydro-power. It is necessary to employ cheaper and expeditious methods of constructing dams and tunnels, large multi-purpose and hydro electric projects should be so planned that interim partial benefits are derived in an economical manner, mini hydro schemes on existing irrigation canals should be taken up to fill up gaps in long gestation projects.

Varma (1992) outlines the development of hydro power in India. The rate of growth of hydro power accelerated during post-independence period.. At present the country has every conceivable type of hydro generation including run of river schemes, storage schemes, pumped storage plants besides hydro generation due to transbasin diversion of water either by gravity or pumping with untis capacity ranging 6 MW to 165 MW each. Though the need for speedy harnessing of balance of hydro potential is realised, resource crunch have slowed down the pace of development considerably, leading to an imbalance in hydro-thermal mix thus disrupting the stable operation of the power system.

The present situation warrants speedy harnessing of balance of hydro potential after ensuring that the impact on environment as well as acquisition of forest lands are kept minimum by adopting suitable measures. Since reasource crunch is also one of the factors which has slowed down the pace of hydroelectric power development, it is hoped that the present policy of the Government of India to allow the participation of private sector in executing the power projects will ease the position to some extent.

Sarkar (1984) explains the efficiency of thermal power stations which depends on the adequate quantity and good quality of coal supplied to the power stations. The quantity, quality and transportation of coal pose different problems for maintaining thermal power generation. It has been observed in a number of cases that the quantity of coal supplied to power stations is short of consumption which results in low coal stocks. The shortage in coal supplies to power stations is due to underloading of the wagons at colleries.

It has been found that the quality of coal supplied to power stations is of low grade which creates problems for boilers and leads to rapid erosion of super heater tubes, economiser tubes and I.D. fans. Coal wagons also carry oversized coal stones and extraneous materials like parts of shovels, iron scrap which damage crushers.

Recommendations for regular quantity and improved quality of coal supplied to thermal power stations are given in this paper.

Chakravarti (1987) throws light on the Government's policy to install super thermal power stations at coal pitheads on an integrated basis under the central sector. It was considered convenient and economical to evacuate power from super thermal power stations to the respective power stations far away from the load centres. The National Thermal Power Corporation is given the charge of many super thermal power projects in different parts of the country. The author lays stress on new technologies and style of management for adequate power generation.

Kumar (1987) throws light on social and economic scenario of thermal plants. According to the author demand for power has been increasing in urban as well as rural areas, yet the power availability from already installed capacity is very poor. Some critics think that this is because most of the power generation is with State Electricity Boards who treats performance as of secondary importance as they function under the bureaucratic system of management, others contribute it to inefficient, unskilled, untrained manpower in power stations. Technology oriented persons suggest the use of washed coal, change in coal combustion system and proper stocking of spares. The author finds that high ash content in coal is responsible for increased pollution and heavy erosion in super heaters and economiser tubes in thermal stations. To increase the load at power plants, demand for the washing of coal before despatch to power stations is favoured.

Singh (1989) investigates whether the Indian thermal power industry is able to realise the economies of scale which are theoretically present across the bigger generating sets. With the help of existing data and some plausible assumptions, the paper gives the impression that the industry can do so. The empirical evidence also reveals that the Indian thermal power industry is capable of taking advantage of the scale-economies prevalent across tha bigger sets. Because of this, the industry shall be encouraged to construct bigger sets.

Sharma (1991) throws light on coal resources in India. Coal is the main input in thermal power generating plants. Coal resources have a wide range of potential use in all forms of its availability. It is an important resource of power generation and could be an important substitute for scare and fast depleting oil and atomic minerals. So, coal has to bear the main burden of power needs of the country particularly in the present day context of shortage of oil, atomic minerals and lack of money to install hydel projects. India has adequate reserves of coal and Government has taken steps to make it available for power generation. The power sector constitute the largest consumer of coal in India. The study suggests that the low rank Indian coal, both processed and unprocessed can be burnt efficiently with modern equipments in thermal plants to meet the growing demands of power.

Gupta (1992) examined the importance and future of thermal power in India. A major portion of total installed power capacity consists of thermal power mainly because of their low gestation period, flexibility of their site selection, ease of augmentation of existing facilities and lesser investment cost required as compared to hydro stations. Past trends in thermal generation in India shows quadruple increase in thermal capacity alone as compared to hydel and others. The rapid increase in larger unit sizes from 15 MW in the forties to 500 MW at present has facilitated quicker capacity addition and increased thermal power generation. The cost of thermal power stations has been showing steady upward trend mainly due to the inflationary impact on material and labour, high cost of technology transfer and also due to the market strategy of the suppliers.

Thermal power generation would continue to play an important role in the Indian power sector due to the large coal reserves available in India and low gestation period of installation. But there is need to improve and develop the technologies which could save, reduce specific investment cost and minimise environmental damage.

Sethna (1980) discussed India's atomic power programme. India is among the eight countries of the world, and only developing country, to have the complete fuel cycle, right from uranium exploration, mining, extraction and conversion, through fuel fabrication heavy-water production and reactors, to reprocessing and waste management. India has also reached a stage where its indigenously developed know-how can support all the required activities encompassing feasibility studies, site selection, detailed project design, construction, commissioning and operation of any plant in the entire fuel cycle chain.

The decade 1966-76 saw the introduction of nuclear power in India. The western, northern, and southern regions of the country were chosen for nuclear power plants because of their distance from coal fields, which are largely concentrated in the eastern and central parts of the country. India's first nuclear power station at Tarapur, near Bombay consisting of 400 MW capacity was commissioned in 1969. Nuclear power in India has not been demonstrated as an economically competitive and safe source of energy only but has also played the invaluable role of a catalyst for the scientific, technical and industrial development of the country as a whole.

Ramanna (1984) examined Indian experiences in nuclear power. The study highlights the progress and status of Tarapur Atomic Power Station, Rajasthan Atomic Power Station, Madras Atomic Power Station and Narora Power Station. Since, the setting up of the Atomic Energy establishment in the mid 1950's, one of the primary objectives has been to achieve self-sufficiency in the technology of harnessing the power of the atom to meet the country's growing power requirements. The demand for electric power has been growing exponentially over the years and the projections indicate that India will have to nearly treble its present electric power generating capacity by the turn of the century. The magnitude of this demands that all proven and available technologies be fully exploited. Paucity of natural non-renewable resources like oil or high-grade coal and restrictions on the availability of hydro potential lead to the conclusion that these resources cannot meet the projected demand for electric power.

Other exotic technologies like solar, wind, tidel etc. are appropriate only for localised applications requiring small quantities of electric power, but they cannot cater to bulk electricity generation. They are feasible either technically or economically. In India, all the inputs for operation of nuclear power plants like heavy water, fuel, high quality fabrication and testing, fuel, reprocessing and waste management are available. The self-sufficiency attained in the field of nuclear power now enables this source of electric power to contribute significantly in meeting the power requirements during the years to come.

Ramanna (1987) emphasises in his paper that nuclear power is the safest and most economic form of producing electric power. It requires very small built-in land areas even when the stations are capable of producing large quantities of power. In this way, they upset the environment the least when compared to hydro and thermal power. Nuclear power has an important role as a source of generating electricity in addition to coal and hydro sources. But, nuclear power requires adequate quantities of uranium. It is therefore, necessary to increase the activity to determine uranium in large deposits in places other than have been found hitherto, preferably of richer quality.

After the chernobyl accident, our newspapers have taken the accident in proper perspective i.e. to consider as a part of the learning process of the world. Future reactors will surely operate more safely under any circumstances as time goes on. Inspite of one or two accidents that have occured in recent times in developed countries. Nobody in advanced countries have even suggested that their power programme based on nuclear energy should be reduced. This is because they realise that nuclear power is the only source of power available in the future. India must not miss this new industrial revolution.

Srinivasan (1987) throws some light on nuclear power in India. The year 1987 marked coming of age of the country's atomic power programme. Since the passing of Atomic Energy Act and the setting up of the Atomic Energy Commission during 1948, the objective of nuclear power programme has been to harness the power of the atom for generating electricity. The success achieved in the developmental phase of this programme culminated in the formation of the Nuclear power corporation of India Ltd. (NPCIL) during 1987, which marked the commencement of "industrialisation" of nuclear power in India. Much thought has been given in recent years to the expansion of country's nuclear power programme. As nuclear power projects are capital intensive, the importance of adhering to schedules cannot be over-emphasized, and the formation of NPCIL is expected to go a long way in ensuring this objective. In addition to the use of modern techniques of construction, the functions of planning and monitoring of nuclear power projects are also being strengthened up.

The Indian nuclear power programme is now entering a commercial power phase wherein the experience gathered to date will be utilised on an industrial scale to step up the nuclear power programme in a significant manner. To a country like India that has the constraints of limited fossil resources and a large population, such a programme can definitely yield significant benefits during the coming decades.

Lal (1979) throws some light on the financial objectives of the State Electricity Board, spelt out in the Electricity (Supply) Act, 1948, which guides the process of power development in the country since independence. The author highlights some special features of electric power supply industry-electric power cannot be stored, flow of electricity and therefore, generation of electricity has to remain uninterrupted continuously all through the year, it is a monopoly business and electric power supply industry is highly capital intensive in nature. The nature of the industry being highly capital intensive has an impact on the financial working of the State Electricity Boards. There are various sources of revenue and expenditure of the State Electricity Boards. Revenue receipts include sale of power, other miscelleneous receipts and any subsidy given by the State Government, capital receipts flow from loans taken from State Government, LIC, Rural Electrification Corporation and market borrowings. Fuel costs, operation and maintenance charges, cost of purchasing power from neighbouring systems and establishment charges are four major revenue experiences. Financial uncertainty in the Boards is due to long term debts which require time consuming negotiation and paper work and involve interaction with several agencies. This results in delays and uncertainities.

Gujral (1980) outlines the capital structure of State Electricity Boards - how it is built, extent of over-capitalization, sources and pattern of financing. The important changes introduced in the financial structure of the Boards by the Electricity (Supply) Amendment Act, 1978, viz. equity participation by States and transfer of the Board's reserves to the State Government in the form of interest payment have been described in detail. Focuss has been set on the controversy whether or not the State Government should convert its loans to the Board into equity capital and the relevance of the concept of debt-equity ratio in the Board. Conversion of loans into equity capital by the State Government bas been found necessary for facilitating market borrowings by State Electricity Boards. In the end, the effect of these changes on the liquidity position of the Board, the task of its top management, its borrowing powers, Government resources etc. have been highlighted.

Upadhya (1982) examined the working of power supply undertaking i.e. State Electricity Boards in India. Though the State Electricity Boards were entrusted by Electricity (Supply) Act of 1948, with the responsibilities of promoting the coordinated development of power generation, transmission and distribution of electric power in their own States in the most efficient and economical manner, still their structural, organisational, procedural, financial and technical aspects are in a sorry state. The power industry needs a thorough and deep study of the causes of failure and breakdowns of plants. Research and development activities should be accelerated in collaboration with I.I.T.s, CSIR laboratories and other public and private sector undertakings like BHEL, Tatas etc.

For proper power supply in the country, modern management system should be implemented in the State Electricity Boards, Maintenance should be improved, there should be a provision of adequate training facilities, State Electricity Boards should be made completely autonomous, importance should be given to the quality of the imported equipments and inter and intra-regional links should be optimally used to maximise generation.

Rao (1984) highlights the major deficiencies in materials management of State Electricity Boards. These deficiencies can be traced to extensive growth in organisation, without corresponding changes in purchase policies and techniques to keep pace with this growth in size and complexity and technological advances. The long administrative lead time and inordinate delays in decision making in purchasing, requiring extensions of validity of tenders, with consequent escalations in costs and increased inventories and multiplicity of purchasing authorities are the most serious deficiencies. Absence of cost-benefit consciousness and of materials planning are also serious. Budgetary control and management information system are conspicuous by their absence or total inadequacy.

State Electricity Boards have been in the limelight for their poor physical and financial performance over the last several years. In view of the constraints on the upward revision of the power tariff to a level that would give the Board adequate reasources, the only remedy is to generate savings, which is possible only in the area of materials management in the present context. In view of massive investments expected in the power sector in the next two decades, the State Electricity Boards have to brace themselves up to deal with large purchase in the material-intensive industry. The registration of suppliers and limited tendering would reduce administrative lead time. Standardisation of equipment and development of suppliers would increase competition. Purchase research would contribute to all round reduction in materials cost, identifying cheaper materials, conducting special studies for cost reduction etc.

Arokiaswamy (1985) throws light on economic viability of electricity boards while fulfilling social obligations. The Electricity (Supply) Act imposes on the Electricity Boards, the social obligations of taking up the uneconomic operations of electrification of rural and tribal areas. At the same time it requires them to ensure not only an adequate, reliable and good quality power supply, but also operate the Board in the most efficient and economic manner. But most Electricity Boards are functioning as huge liabilities for the respective states. The precious plan funds meant to create new assets are being diverted to make up operating losses. Some of the Boards have no money to buy materials and complete the on-going projects or to connect up new services or to maintain a reasonably good quality power supply without power cut and load sheddings for existing consumers. They have accumulated huge outstanding dues to BHEL, NTPC, NLC and CIL etc.

Enabling the power Boards operation economically viable while fulfilling several social obligation is not impossible, provided the State Governments muster a strong political will, not only to avoid interference but also initiate several measures as hiking up of tariffs, reducing excessive subsidies and plugging revenue leakages by theft and pilferages. The Government of India has also to introduce several legislative measures and Central Electricity Authority must also actively assist the Boards to implement the necessary measures.

Verma (1986) highlighted the capital structure of State Electricity Boards. The capital structure of the State Electricity Boards is debt ridden as it is comprised mainly of fixed interest bearing capital. The State Electricity Boards have no capital of their own other than loans. There is no equity and preference share capital in the capital structure of the State Electricity Boards. All the SEBs have raised their capital only by way of longterm debts and internal sources. The capital structure reveals that the State Electricity Boards have financed to the extent of 82 per cent by way of loans and about 18 per cent from internal sources. Out of long term debts, the share of Government loans was about 70 per cent as compared to remaining 30 per cent from non-budgetary sources.

There are permissive provisions as per the amended Electricity Supply Act, 1978 for the issue of share capital upto rupees ten crores. Conversion of the part of the loan into share capital is also permissible. But these provisions of the Act are not acted upon by the State Governments with the result, all the State Electricity Boards continue to bank upon borrowed capital exclusively. To improve the financial position of the State Electricity Boards, it is suggested that the capital of the State Electricity Boards should be restructured by converting a part of the loan capital into equity capital. Conversion of loan into equity capital will not only reduce the interest burden, but also relieve the Boards in the matter of repayment of loans to creditors, other than the State Government. This will improve the financial performance, thereby enabling them to raise enough internal resources to finance their expansion programme. The availability funds to State Electricity Boards from non-budgetary sources must be increased by making it easier for them to obtain loans from Life Insurance Corporation, other financial institutions and raising the equity capital. The State Electricity Boards should step up internal resources by reducing the cost of power generation, overheads and transmission and distribution losses.

Arokiaswamy (1988) has done a case study of the financial performance of Tamil Nadu State Electricity Board. The study shows that the Tamil Nadu State Electricity Board incurred huge losses during 1984-85. Actually only a few State Electricity Boards are making profits, whereas most are incurring heavy operating losses. Profitable functioning of a State Electricity Board can be attained either by increasing revenues or by reducing expenses. But it requires a strong political will on the part of the State Government to permit the State Electricity Board to accomplish the above, because, the political system has used several State Electricity Boards including Tamil Nadu State Electricity Board to gain popularity by stretching too far subsidies to several consumers including undeserving ores. There is a need to augment revenues of State Electricity Boards from agricultural sector, domestic sector, industrial and commercial sector to reduce the losses incurred by them. By creating more internal resources, the State Electricity Boards would be in a position to generate more to meet the power needs of the country.

Kochar (1978) highlights importance of rural electrification for agricultural sector. Water is the primary need of agriculture. The irrigation facilities can be created through major surface irrigation projects and minor irrigation. The scope of surface irrigation is limited but there is substantial potential of underground water which still remains to be exploited. The most economical method of pumping out underground water is with the help of electric power pumpsets. During the past few years, energisation of a large number of pumpsets through rural electrification has given a great boost to increased agricultural production in the country. Thus rural electrification in India has made energisation of pumpsets possible resulting in increased agricultural production.

The rural electrification programme was given considerable importance during the Fourth Plan and the subsequent period. In order to accelerate rural electrification programme in the country, the Government of India established Rural Electrification Corporation in 1969. The Rural Electrification Corporation has been functioning as a developmental financing organisation. Low load density, long distribution lines, poor load factor and poor power factor are some problems which make rural electrification a bad financial proposition. To avoid these problems, the construction, operation and maintenance standards should be improved.

Dua (1987) focusses on updating technology in rural electrification and mechanised construction techniques to improve quality of power supply. The programme of rural electrification has been accorded high priority because electric power is seen as the most vital instrument for economic development which increased agriculture and industrial production. More than 70 per cent villages have been electrified, resulting in large number of energisation of electric pumpsets for irrigation. Rapid increase in irrigation facilities has resulted in manifold increase in agricultural production. The country has achieved self sufficiency in foodgrains inspite of rapid growth in population.

Rural electrification requires costly infrastructure. Rapid expansion of the dsitribution network in the country has not been accompanied by proper strengthening of the system which has led to serious deficiencies. While some of the system deficiencies may be attributed to financial constraint, many of the existing problems can be solved by adopting appropriate technologies. This paper attempts to bring out some of the new technologies which can help to solve the existing problems and will make the system inherently more efficient and reliable.

CHAPTER - II

POWER SECTOR IN INDIA

Power is the most preferred form of energy due to its versatility and convenience both in its use as well as its generation, that is why its demand and supply both have been increasing much faster, compared to other forms of energy. Power industry in India has developed into one of the most important basic industries of our economy.

"The power sector is a vital part of the infrastructure of the Indian economy. The performance of the power industry and the economy at large are closely linked, since the bulk of electricity generated is consumed in one of the other productive sectors of the economy. Because electricity cannot be easily traded internationally and because its use is instantaneous and it can not be stored readily, a shortage of electricity supply has an almost immediate effect on the rest of economy." (Taylor, C. 1979)

Power as a basic input for industrial and agricultural growth in particular, and in improving the quality of life ingeneral has been given due recognition in India since independence. Energy in the form of electric power is essential for self-sufficiency in food production and virtual elimination of dependency on imports of essential commodities and industrial input. A high priority has always been attached to the power sector by the Government of India and about 15 per cent to 20 per cent of the total plan outlays have been earmarked for the power sector in successive plans.

In this chapter, an attempt has been made to examine the overall growth of the power industry in India. The time profile of installed capacity, actual generation and demand for electricity have also been analysed.

2.1 GROWTH OF POWER SECTOR IN INDIA

Before independence there were very few and small power stations in India which were owned and operated by private as well as public establishments. The first hydro-electric plant in India was commissioned near Darjeeling in 1897 and the first steam power plant was set up in Calcutta in 1899. Another hydro-electric plant was established in Mysore in 1902. These were followed by several hydro-electric and thermal power plants mainly for serving the needs of urban population and industrial demand. The most impressive power development scheme implemented before 1919 was the 50 MW Kapoli hydroelectric scheme of Tatas to provide power supply to Bombay area. These developments gradually led to electricity establishing itself as the most versatile and convenient form of energy and to the recognistion that it was an essential pre-requisite for industrial development. *The Indian industrial commission 1916-18 stressed the* importance of power development in the country and emphasised the need for a detailed hydro-electric survey to enable systematic development of water power resources. Before independence the power generation and consumption situation was very poor in India, inspite of abundant resources and potential. What little development had taken place was mainly confined to the urban and industrial areas like Bombay, Calcutta Ahmedabad and Kanpur.

In 1910, Indian Electricity Act was passed to regulate the actions of individual private undertakings, inspite of this Act, growth of power generation was very slow. The period between the two World Wars witnessed development of the Paykara, the Mittur, and the Papanasanam hydro-electric projects in Madras, Uhl river-project in Punjab, the chain of power stations along the Ganga canal in U.P., Pallivasal project in Travancore and expansion of Mysore Project. Thermal power continued to develop in all important urban centres as a close preserve of private enterprise. Tatas expanded their hydro-stations along the Western Ghats close to Bombay. The effort during World War-II was mainly to orient power supply industry to war purposes. As a result there was stagnation in power development during that period. The total installed capacity which was about 1.14 million KW in India at the beginning of World War-II increased to only 1.33 million KW at the time of independence.

In 1938, National Planning Committee of the Congress made a number of recommendations for the growth fo electric power generation and consumption. These recommendations remained the guiding force behind the power policy after independence in India.

Progress in power sector is very impressive in the post-independence era, since our planners realised the importance of power sector for agricultural and industrial development. The first step that was taken soon after independence was to introduce a legislation to restructure the power supply industry and to promote and rationalise power development in the country. The Constituent (legislative) Assembly passed the Electricity (Supply) Act on 10th September, 1948, to provide for rationalisation of production and supply of electricity. This new Act provided for the establishment of Central Electricity Authority and organisations in the states, known as State Electricity Boards. The Central Electricity Authority was charged with the function of developing the national power policy and co-ordinating the power development particularly in relation to the control and the utilisation of national power resources. In accordance with the provisions of the Act, the State Governments, established Electricity Boards in their respective areas during the period from 1950 to 1967. These boards are entrusted with the general work of promoting power generation, transmission and distribution facilities within their respective states in the most efficient and economic way and with special consideration to backward and rural areas.

The industrial policy resolution in 1956 included power generation and supply in the group of industries, the development of which was made an exclusive responsibility of the State. These measures led to gradual nationalisation of the power supply industry.

The Planned development of the economy was initiated in 1951 to improve the socio-economic conditions of the people. Development of power was given a very high Priority in the plan programmes. The main objective of power development since independence has been to increase power availability and extend power supply to all regions of the country. The progress under the Five Year Plans has been impressive both in absolute terms and in terms of growth. The installed generating capacity which was 1.835 MW at the beginning of the First Plan in 1951 increased to 69,025 MW in 1991-92.

In India, power is generated from conventional and nonconventional resources. There is a wide range of commercial fuels from which electric power can be generated. These fuels include fossil fuels like coal, gas and petroleum products, nuclear materials as well as renewable sources of energy such as biomass,geothermal and hydro source. The non-conventional power resources are biogas, solar and wind energy. But in India there are three main types of plants for electric power generation, namely thermal, hydel and nuclear.

2.2 GROWTH OF INSTALLED POWER CAPACITY IN INDIA

The generation capacity determines, the maximum limit of power generation available during a particular period. Investment trends in power sector indicates that by allocating more and more financial resources in each succesive plan, the Government of India has significantly increased the generation capacity after independence. Table 2.1 shows the installed power capacity in India.

TABLE - 2.1

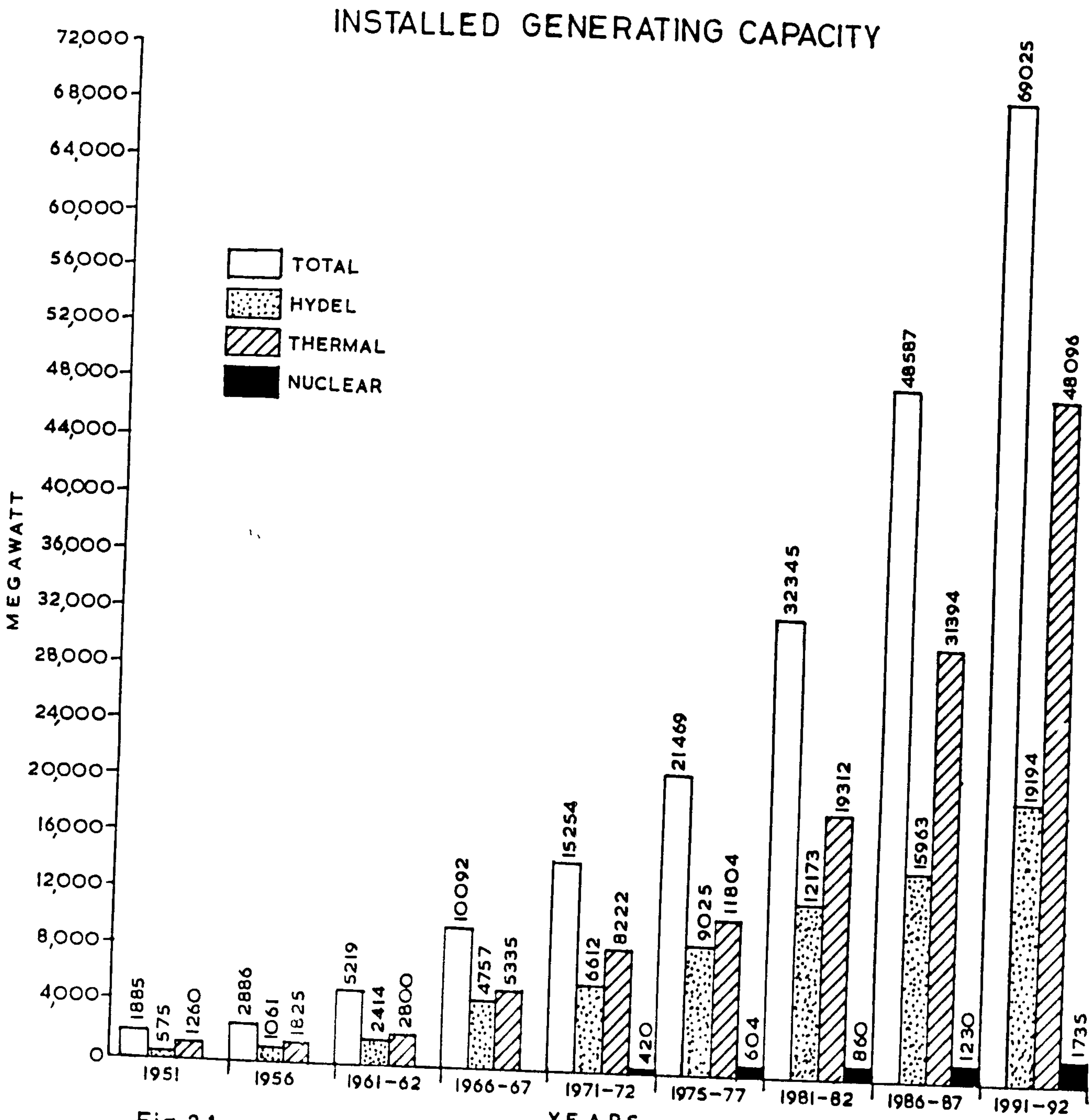
INSTALLED POWER CAPACITY IN INDIA

(in MW)

Year	Hydel	Thermal	Nuclear	Total
1950	559	1,153	-	1,712
1956	1,061	1,825	-	2,886
1961-62	2,419	2,800	-	5,219
1966-67	4,757	5,335	-	10,092
1971-72	6,612	8,222	420	15,254
1976-77	9,025	11,804	640	21,469
1981-82	12,173	19,312	860	32,345
1986-87	15,963	31,394	1,230	48,587
1991-92	19,194	48,096	1,735	69,025

Source: All India Statistics, Central Electricity Authority, 1991-92.

The total installed power capacity in India has increased from 1,712 Mega Watts (MW) in 1950 to 69,025 MW in 1991-92 registering 9.2 per cent compound annual growth. The decadal study reveals that compound annual growth rate is fluctuating all the time (Appendix 2.1). The gap between hydel and thermal capacities was not very significant till 1965-66 (Appendix 2.1). During this period 4,124 MW was obtained from hydel resources and


INSTALLED GENERATING CAPACITY
72,000
68,000
64,000
60,000
56,000
52,000
48,000
44,000
40,000
36,000
32,000
28,000
24,000
20,000
16,000
12,000
8,000
4,000
0
MEGAWATT
TOTAL
HYDEL
THERMAL
NUCLEAR
1885
575
1260
2886
1061
1825
5219
2414
2800
10092
4757
5335
15254
6612
8222
420
21469
9025
11804
604
32345
12173
19312
860
48587
15963
31394
1230
69025
19194
48096
1735
1951
1956
1961-62
1966-67
1971-72
1975-77
1981-82
1986-87
1991-92
YEARS
Fig. 2.1

4,903 MW from thermal stations. Table 2.1 reveals that from 1966-67 the gap in installed power capacity between thermal and hydel resources started widening. During The Fourth Five Year Plan, greater emphasis was laid on thermal power project. In 1969-70 (Appendix 2.1) power was obtained from nuclear sources for the first time.

Hydel power capacity has increased from 559 MW in 1950 to 19,194 MW in 1991-92 recording 8.8 per cent of compound annual growth rate. The decadal study shows that compound annual growth has been decreasing (Appedix 2.1). Thermal power capacity was 1,153 MW in 1950. It has increased to 48,096 MW in 1991-92 registering 2.3 per cent of compound annual growth rate (Appendix 2.1). Nuclear power capacity has also increased from 420 MW in 1969-70 to 1735 MW in 1991-92.

2.3 GROWTH OF POWER GENERATION IN INDIA

With the rise in generating capacity, power generation has been continuously increasing since 1950-51. Bulk of electricity generation has taken place from coal. Table 2.2 shows the power generation in India.

TABLE - 2.2

POWER GENERATION IN INDIA

(Million Units)

Year	Hydel	Thermal	Nuclear	Total
1950	2,520	2,587	-	5,107
1956	4,295	5,367	-	9,662
1961-62	9,814	9,856	-	19,670
1966-67	16,734	19,642	-	36,376
1971-72	28,024	31,712	1,189	60,925
1976-77	34,886	50,245	3,252	83,333
1981-82	48,565	69,515	3,021	1,22,101
1986-87	53,764	1,28,818	5,023	1,87,605
1990-91	72,599	2,08,551	5,561	2,86,711

Source: All India Statistics, Central Electricity Authority, 1991-92.

Table 2.2 shows that power generation increased rapidly from 5,107 million units in 1950 to 286,711 million units in 1991-92 recording 11.3 per cent compound annual growth rate. The decadal study reveals that compound annual growth rate remained the same (12.7 per cent) from 1950-51 to 1960-61 and from 1960-61 to 1970-71. It was 7.1 per cent from 1970-71 to 1980-81 and increased to 9.1 per cent from 1980-81 to 1990-91 (Appendix 2.2).

POWER GENERATION

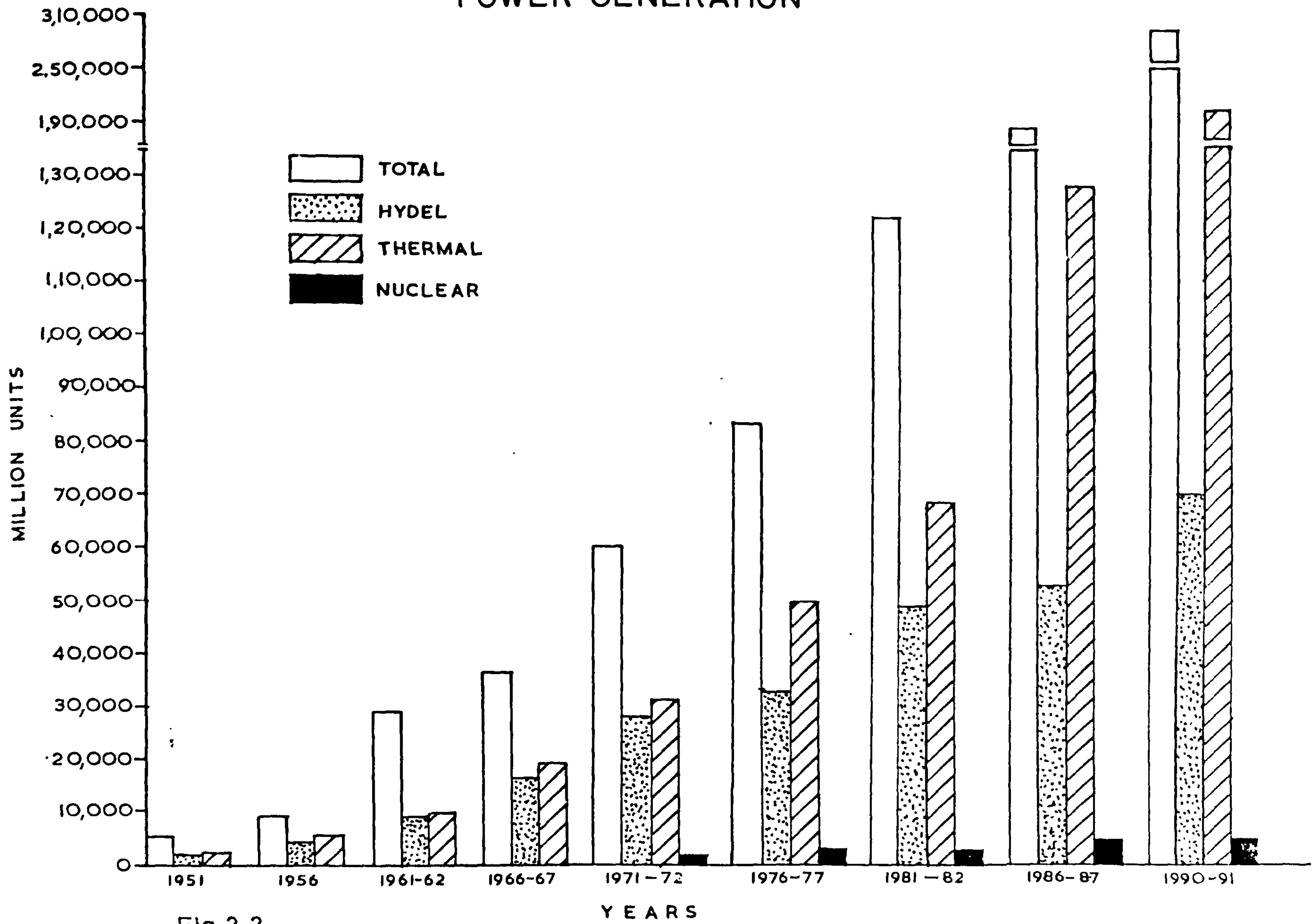


Fig. 2·2

The generation of hydel electricity was 2,520 million units in 1950. It had increased to 72,599 million units during 1991-92 registering 8.2 per cent compound annual growth. The decadal study reveals that generation by water resources remained constant for two decades after which it was decreased considerably (Appendix 2.2).

The generation of thermal power was 2,587 million units in 1950 which increased to 208,551 million units in 1991-92 registering 11.2 per cent of compound annual growth. Though generation is continuously increasing, the decadal study reveals that compound annual growth rate has been decreasing (Appendix 2.2). The generation of nuclear power has increased from 1,339 million units in 1969-70 to 5,561 million units in 1991-92.

2.4 CONSUMPTION OF POWER

Comsumption of power is one of the basic indicators of growth and productivity of national economy. Power consumption in the country has grown at a faster rate over the decades.

"Consumption of electricity has grown rapidly in relation to net domestic product. Between 1960-61 and 1975-76, the annual average growth rate of the former was 10.2 per cent while that of the latter was 3.4 per cent." (Taylor, C. 1979).

TABLE - 2.3

CONSUMPTION PATTERN IN DIFFERENT CATEGORIES

Energy Sales (GWH)

Year	Total	Domestic	Commercial	Industrial	Traction	Agriculture	Others
1950	4156.66 (100)	424.59 (12.6)	308.75 (7.5)	2603.81 (62.6)	308.41 (7.4)	161.68 (3.9)	249.42 (6.0)
1956-57	7959.35 (100)	934.11 (1.7)	545.84 (6.8)	5323.43 (66.9)	404.93 (5.1)	316.18 (4.0)	434.85 (5.5)
1961-62	16448.29 (100)	1698.08 (10.3)	934.09 (5.7)	11545.60 (70.2)	584.76 (3.6)	991.14 (6.0)	695.22 (4.2)
1966-67	29127.64 (100)	2626.78 (9.0)	1819.62 (6.2)	20390.80 (70.0)	1180.22 (4.1)	2110.50 (7.2)	1003.78 (3.5)
1971-72	47063.20 (100)	4107.46 (8.7)	2952.78 (6.3)	31637.18 (67.2)	1632.69 (3.5)	5005.62 (10.6)	1637.47 (3.7)
1976-77	60608.57 (100)	6336.57 (9.51)	4141.92 (6.22)	41605.63 (62.47)	2167.72 (3.25)	9620.63 (14.44)	2763.11 (4.11)
1981-82	90245.33 (100)	10439.62 (11.57)	5194.41 (5.76)	53063.79 (58.80)	2504.72 (2.78)	15201.16 (16.84)	3041.63 (4.24)
1986-87	135952.08 (100)	19323.13 (14.21)	7772.07 (5.72)	70296.87 (51.71)	3229.41 (2.37)	29443.96 (21.60)	5886.64 (4.33)
1989-90	174819.57 (100)	28173.93 (16.12)	10227.20 (5.85)	80878.10 (46.26)	4150.38 (2.37)	43643.01 (24.97)	7744.95 (4.43)

Note: Figure in brackets indicate the per cent of the total sales.

Source: All India Statistics, Central Electricity Authority, 1989-90.

Consumption of power is divided into various sectors like domestic, commercial, and industrial etc. The consumption of power by various sectors is presented in table 2.3. It is clear from table 2.3 that the largest share of power goes to industrial sector followed by agricultural and domestic sectors. The pattern of power consumption has undergone a tremendous change. The share of agricultural sector in the total power consumption in the country has gone up rapidly from 3.9 per cent in 1950-51 to 24.97 per cent in 1989-90 while the share of industrial sector decreased to 46 per cent in 1989-90 from 62.6 per cent in 1950-51. Table 2.3 indicates that from 1950 to 1988-89 there has been an increase in domestic consumption from 12.6 per cent in 1950 to 16.12 per cent in (1989-90). Power consumption in the agricultural sector might have increased due to energised pumpsets, mechanised pillars and harvestors. There is a nominal decline in the case of commercial consumption from 7.5 per cent in 1950 to 6.19 per cent in 1988-89. Consumption of power in traction declines from 7.4 per cent in 1950 to 2.37 per cent in 1989-90.

2.5 POWER SHORTAGE

Consumption pattern shows that the demand for power is continuously increasing at a rapid rate outstripping the availability for the power. This has resulted in continued shortages of power in various parts of the country. Power shortage continues to prevail in the country despite, increase in installed capacity and improvement in power generation.

Power shortage hinders the economic growth of modern economy and affect industry, agriculture and household sectors adversely.

TABLE - 2.4

POWER DEMAND AND SUPPLY

(Billion Units)

Year	Demand	Supply	Deficit(%)
1980-81	120.1	104.9	12.6
1981-82	129.2	115.3	10.8
1982-83	136.8	124.2	9.2
1983-84	145.3	129.7	10.7
1984-85	155.4	145.0	6.7
1985-86	170.7	157.3	7.9
1986-87	192.4	174.3	9.4
1987-88	211.0	188.0	10.9
1988-89	223.2	205.9	7.7
1989-90	247.8	228.2	7.9
1990-91	267.6	246.6	7.9
1991-92	289.0	266.4	7.8

Source: Current Energy Scene in India, CMIE, May 1993.

POWER SHORTAGE IN INDIA

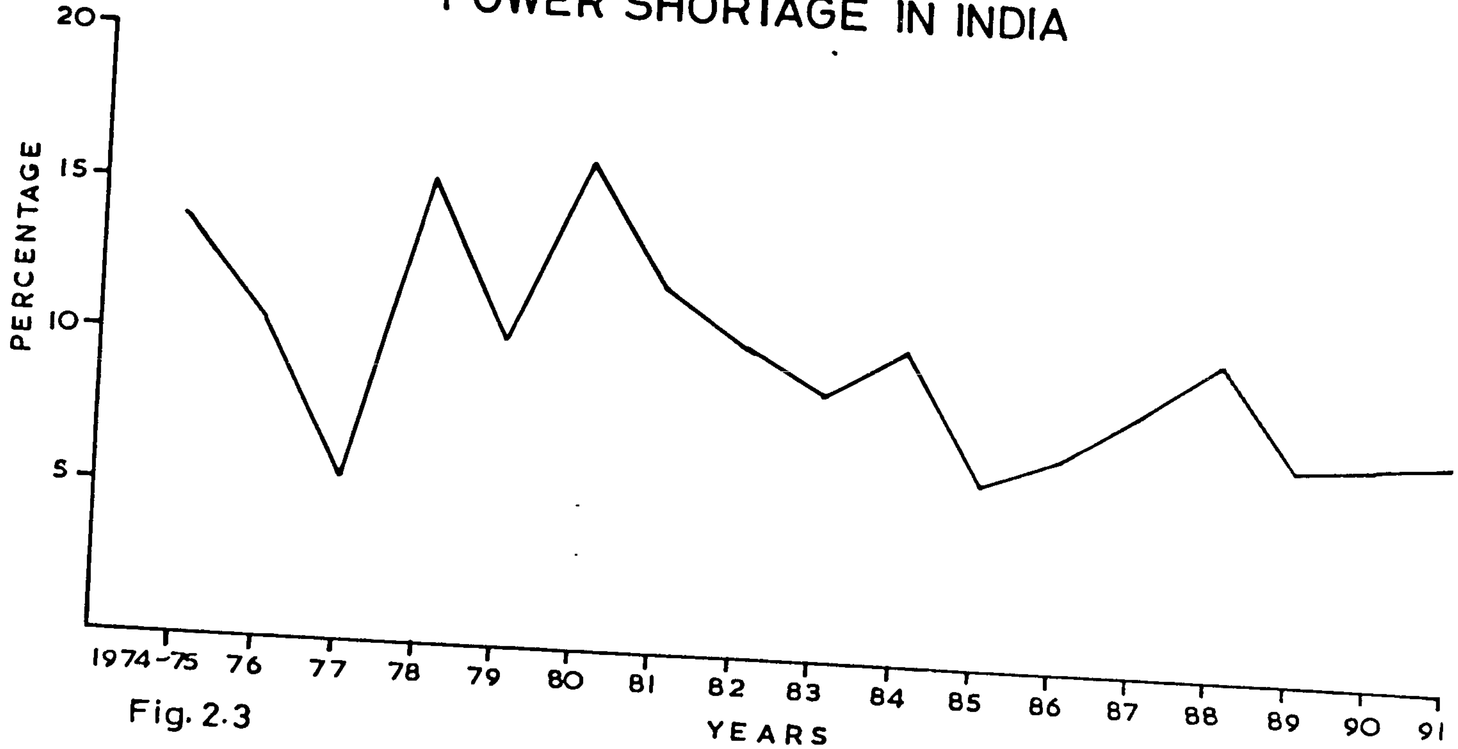


Fig. 2.3

Table 2.4 shows that supply has been falling short of demand which affects regular supply of power. The gap between demand and supply has benn increasing, inspite of the fact that over 60,000 MW of installed capacity has been added in the post independence era.

2.6 POWER DEVELOPMENT DURING FIVE YEAR PLANS

During five year plans emphasis has been laid to increase installed capacity and generation to meet the growing demand. The First Five Year Plan from 1951 to 1956 mobilised country's resources in such a way that the impetus needed for power industry was available. The First Five Year Plan provided an expenditure of Rs.260 crores, about 13.3 per cent of the total plan outlay, which included propotionate cost of multipurpose projects. The First Five Year Plan included a number of multipurpose river valley projects, with hydro electric power generation as an important component, because when the Plan was drawn up, the country was facing serious food shortage and emphasis was laid on extension of irrigation facilities and improvement in agricultural practices. The major multipurpose river valley project undertaken during this period was the Bhakra Nangal Project which was planned to irrigate vast areas of land in Punjab, Haryana, and Rajasthan and afford electricity generation with a total installed generating capacity of 1240 MW. The Plan also included unified development of Damodar valley for the purposes of providing flood control irrigation and power supply in the Damodar-Valley area. The Tungabhadra and Hirakund river valley projects were also undertaken during this period. The aim of the Plan was to add 1,300 MW of installed capacity, but it could increase only 1,100 MW of additional installed capacity. It is clear from table 2.5 that there was nearly 15.4 per cent shortfall in achieving the Plan target. Althought the transmission Lines were almost doubled during this period targetted growth in the installed generating capacity could not be achieved due to delay in investigation and commissioning of the projects, prolonged delay in deliveries of the imported plants and machineries and difficulties in obtaining basic materials like steel, cement, etc.

The second Five Year Plan which was deviced to produce rapid industrialisation laid emphasis on the power sector. It had three aims in respect to power development

(1) To meet the normal laod growth in the existing power system.

(2) To provide the requisite capacity for reasonable expansion of the areas of supply.

(3) To meet the needs of industries which were to be eastablished under the Second Five Year Plan.

The Second Five Year Plan provided an expenditure of Rs. 460 crores, though as a percentage of total plan sharing, it fell to 9.8 per cent. Almost 60 per cent of total outlay was on generation to double it at the level of 6.9 million KW by the end of Second Plan. The brunt of this effort was to be borne by State-owned undertakings, an addition of 2.9 million KW was envisaged in the public sector, a percentage increase of 207 per cent or 3.48 million KW in generating capacities over the last year of First Plan. However at the end of the Plan only 2.5 million KW could be added to the existing capacity as against an intial target of 3.48 million KW, resulting in 35.7 per cent shortfall in achieving the Plan target. The shortfall in achieving the target was mainly due to foreign exchange difficulties that arose during the early years of the Second Plan and also due to delays in the execution of some of the river valley project and key materials like steel, cement etc. were also in short supply. The Second Five Year Plan put a greater stress on the hydro-electricity. Integrated development of Chambal Valley for irrigation and power benefits in Rajasthan and Madhya Pradesh was taken up during this plan. Besides these multipurpose projects, a number of single purpose hydro-electric projects were taken up. This includes the Koyna project in Maharashtra and Kundah project in Tamil Nadu. Several thermal power plants were also taken up to augment power supply to meet the power needs of the infrastructure industries. Due importance was also given to rural electrification and extention of electricity supply facilities to remote areas in the country. As in the case of the First Plan, the Second Plan envisaged doubling of transmission mileage but there was no special recognition of the need for transmission facilities growing in step with generating capacity. Emphasis was laid only on the foundation of a grid system and its advantages. The total installed capacity at the end of the Second Plan rose to 4653 MW.

At the time the Second Plan was formulated, most of the state governments were still managing the electricity undertakings through their public work departments. It was considered that organisation of electricity boards with the semi—autonomous power vested in them would be suitable for the construction and operation of power schemes.

The Third Five Year Plan (1961-66) continued to lay emphasis on infrastructural facilities for industrial development. The Third Plan gave priority to rural electrification to increase power supply to rural areas particularly for energisation of pumpsets. In the early years of the plan, steps were taken to arrange foreign exchange for implementing the remaining power schemes of the Second Plan. Work was also taken up on a few additional schemes not included in the Second Plan, to meet the increasing demands that arose in certain regions. While the rate of growth of generating capacity averaged 0.45 million KW per annum during the Second Plan, the Third Plan envisaged stepping up this rate to 1.4 million KW. To achieve this target a provision of Rs. 1252 crores was made for this plan. After the experience of the Second Plan in importing electrical equipments, steps were taken to establish heavy electrical plants in the country. The importance of co-ordinated development of electricity supply with regions as spatial units for development was recognised. The Third Plan document postulated that all power stations should be inter-connected to form state, zonal or super-grid so that the energy is pooled and used to the best advantage of the region. Inter-state collaboration in the execution of river valley projects were further extended so that power generation may be undertaken on a regional basis and not merely to meet the demands of one state alone. Likewise, steps were taken to divide the country into five convenient regions and Regional Electricity Boards were established in each region for promoting integrated operation of constituent power systems. The five regions are:-

Northern Region-Jammu and Kashmir, Himarchal Pradesh, Haryana, Delhi, Uttar Pradesh, Rajasthan and Chandigarh.

Western Region-Gujarat, Maharashtra and Madhya Pradesh.

Southern Region-Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa and Pondichery.

Eastern Region-West Bengal, Bihar, Orissa and Damodar Valley Corporation.

North Eastern Region-Assam, Manipur,Tripura,NEFA and Nagaland.

As against the target of 7,043 MW of installed capacity the actual capacity commissioned during the Third Plan was 4,520 MW. This shortfall of 35.8 per cent in achievening the envisaged plan target was mainly due to outbreak of hostilities in 1962 and 1965 and also due to delayed implementation of the power projects. The reasons for the shortfalls were:-

(1) procedural delays in getting the projects finally accepted by foreign aid giving agencies, although they were tied up in principle with foreign credit,

(2) shortage of free foreign exchange to import ancillary equipment not covered by foreign aids,

(3) procedural delays in the appointment of consultants,

(4) procedural delays in placing orders for equipments,

(5) delays in deliveries or equipment from certain countries, and

(6) delays in civil works.

The Three Annual Plans (1966-69) gave priority to the schemes carried over from the Third Plan and specially those in the advance stage of construction. The significant feature in the power development in this period was the initiation of nuclear power development at Tarapur with the 400 MW power plant. The progress of power development under these plans was also rapid. The high voltage transmission in the country at the level of 200 KV had been set up in all the regions. The need for providing electricity for agricultural pumping to stabilise agricultural production was recognised and a massive rural electrification programme specially oriented to agricultural pumping was initiated during the later part of the third Plan. The number of villages electrified increased to 73739 and the number of pumpsets exceeded one million mark by March, 1969. The power sector investment was nearly 10.43 per cent of the total plan outlay. A total sum of Rs. 1,213 crores was provided to the power sector which led to an addition of 4,120 MW in total power generation capacity. However, this was less than the targetted growth of 5430 MW during this period. As a result there was an overall shortfall of 24.1 per cent in achieving the plan target during the Three Annual Plans.

The most significant feature of the Fourth Five Year Plan was the realisation of the need for greater participation by the Central Government, in the expansion of power generation programme in order to supplement the efforts of the States. During this plan emphasis was laid on inter-state and inter-regional lines to reduce the imbalance between generating capacity and the transmission and distribution facilities. The first three plans exceeded a rapid increase in capacity and between 1959 and 1969 it was almost doubled. As a result, the distribution became all the more important, by March 1969, the installed capacity in utilities rose to about 12,960 MW (5910 MW in hydro, 6640 MW in thermal and 410 MW in diesel and gas). The Fourth Plan provided Rs. 2932 crores on electric power development, which was nearly 18.6 per cent of the overall public sector outlay during the plan. Out of this, over Rs. 1061 crores was set apart for addition to the generating capacity. It was proposed to add installed generating capacity of 8264 MW but the target could not be achieved as only 4579 MW of installed capacity was added. One of the main features of the Fourth Plan was that emphasis was laid on extension of electricity facilities to rural areas under minimum needs programme. Two important steps were taken towards rural electrification (i) establishment of rural cooperatives, and (ii) Rural Electrification Cooperation. The power programme in this plan included three hydro-electric projects viz, Salal (345 MW) Bairasiul (180 MW) in the Northern Region and Loktak (105 MW) in North Eastern Region and the Badarpur thermal power project in the Central Sector. The Fourth Plan also marked the transition to self reliance in equipment supplies for power project. The first nuclear power station in the country went into operation during this plan period. Despite setting up of three hydro-electric power projects (530 MW) and a nuclear power plant (Tarapur), acute power shortage was faced during this plan as there was a vast gap between demand and supply. A a result transmission and distribution were identified as a major problem areas.

The Fifth Five Year Plan gave priority to speed up the construction programme and commissioning of power generation projects and also maximising generation from the available capacities. Two central organizations namely, National Thermal Power Corporation and National Hydro-Electric Power Corporation were set up in 1976 to promote development of super thermal power stations mainly located close to pit heads and establishment of major hydro-electric project on regional and national considerations. During the Fifth Plan, the power generating projects continued to increase and around 10,202 MW of installed electric power capacity was added to existing capacity. Work on a large pit head station at Neyveli in southern region was also started. It was during this period that thermal power plants started adoption of large units of 200 MW as standard unit size for generation of power. The first 200 MW unit was commissioned in Uttar Pradesh at Obra in December, 1977 and this was succeeded by installation of a more units by the end of Fifth Plan. Another thermal unit of 500 MW was started at Trombay in Bombay in the same year. Nuclear power also progressed under the plan with the comissioning of the first unit of the 210 MW pressurised Heavy Water Reactor (PHWRs) based plant in Rajasthan. Significant progress has also been made in increasing transmission and distribution facility, besides, improvements in the technology. The highest transmission voltage in commercial transmission of electricity went upto 400 KV in the country for the first time, connecting long distance 400 KV transmission line of Obra-Sultanpur in Uttar Pradesh in 1978. Besides, additional 400 KV lines have been initiated in all the major power systems in the country. The number of pumpsets energised by March, 1979 went upto 36.0 lakhs and the number of villages electrified had gone upto 2.33 lakhs. By the end of the Fifth Plan the country had well connected power systems making exchanges of power between a large number of state/system and this facilitated better utilisation of the available capacity and mitigating shortages in several systems. The plan outlay on power sector increased during the Fifth Plan. A total sum of Rs. 7,400 crores was provided for power sector in the country which amounted to 18.8 per cent of the total public sector outlay. The entry of central involvement helped in proliferation of both capacity generation and investment. The plan had set the growth target of installed capacity at 12,499 MW. However, at the end of the plan period there was nearly 18.4 per cent shortfall in achieving the plan target.

The Sixth Five year Plan gave high priority to increase power supply in the country and achieve a balance between supply and demand as early as possible. The main emphasis of the plan was to improve the functioning of thermal power stations. Attention was given on early stabilisation of 200/210 MW units. At the end of the Sixth Plan, a comprehensive renovation and modernisation programme for poorly functioning thermal power plants was approved as a centrally sponsored scheme at an estimated cost of Rs. 500 crores. In the Sixth Plan, an outlay of Rs. 18,299 crores was provided for power development which was 16.7 per cent of the overall public sector outlay. The plan had envisaged to add 19,666 MW of installed generating capacity, but at the end of the plan the actual increase of installed capacity was 14,266 MW only. However this shortfall of 27.7 per cent in achieving the plan target was due to delays in the commissioning of projects, extending in some cases to many years because of poor project management and lack of funds. However, an addition of 14,226 MW in the total installed capacity of power plants represented an increase of 49.4 per cent. The target of installed capacity for nuclear power was 690 MW, out of which 455 MW was achieved with the commissioning of the second unit of 220 MW at Rajasthan Atomic Power station in April 1981 and Madras Atomic power station unit I of 235 MW in 1983, the installed nuclear power capacity increased to 1095 MW by the end of the plan. The average gestation period of the thermal power plants which had gone up substantially during the Fourth

Plan has been brought down. Some thermal generating units have been commissioned in a period of 40 months from the date of placing of orders for the main equipments. The industry has been able to achieve an average addition of 3000 MW per year during the Sixth Plan against an average of 2000 MW during the Fifth Plan. The larger power programmes taken up in the central sector during Fifth Plan began to yield benefits from 1982 onwards. An important feature of the programme has been the project implementation according to sechedule and without any serious cost over-runs. The Sixth Plan did not include specific physical targets for transmission lines. Investment on transmission and distribution remained static around 27 per cent. Problems were faced in distribution of power mainly from central super thermal power stations. A shortfall of 30 per cent was recorded in regard to energisation of irrigated pumpsets. During the plan period the number of villages electrified had gone upto 370332 and pumpsets energised went upto 5708563. Though the Sixth plan emphasised on augmentation of the generation in thermal power stations, but the actual results were not upto expectations as the plant load factor in thermal Stations was only 50.1 per cent at the end of the Sixth Plan, far below the level of 55.6 per cent achieved in 1976-77. Due to shortfall in the capacity additions, unsatisfactory performance of thermal stations and non completion of transmission lines, the condition of power shortage continued during the Sixth Plan but it decreased from 16.1 per cent in 1979-80 to 6.1 per cent in 1984-85.

The Seventh Five Year Plan laid emphasis on augmentation of power availability in order to achieve the generation target and construction of transmission and distribution facilities, besides, the Seventh Plan also gave importance to the programme of renovation and modernisation, research and development and training in power sector. The Seventh Plan provided an expenditure of Rs. 34,273 crores for power development. The target of additions to the installed capacity for this plan was 22245 MW. At the end of the plan 21402 MW of installed capacity was added to existing capacity, resulting in 3.8 per cent shortfall in achieving the plan target. It is clear from table 2.5 that planwise slippages in new generating capacity at 3.8 per cent was less during this plan compared to other plan period. The actual capacity addition during this plan was about 50 per cent. High priority was given to reduce power shortage by improving the performance of existing power plants in this plan period. The emphasis was also laid on small, micro and mini hydel units to maintain the balanced growth of power in the country. The hydel-thermal mix which was 40:60 at the end of the Fifth Plan, was 33.7:66.3 at the end of the Sixth plan. To reduce this imbalance in hydel thermal mix, small hydro units were being introduced.

The role of central sector also increased during the Seventh Plan. The share of the central sector in the total installed capacity was 9.70 per cent in 1979-80, 13.3 per cent in 1984-85, it rose to 22.1 per cent at the end of the plan. Transmission lines of 400 KV and 220 KV were given high priority in this plan. During this plan one unit of 235 MW capacity of nuclear power was also commissioned at Narora. The plant load factor of thermal power stations has also registered an increasing trend during the plan period.

The total capacity addition during 1990-91 and 1991-92 has been 5803 MW consisting 4702 MW of thermal, 881 MW of hydel and 220 MW of nuclear capacity. But this was a low annual rate of capacity addition than in the Seventh plan.

The main features of the approved power programme during the Eighth plan (1992-97) are

(i) induction of additional generating capacity of 31,115 MW,

TABLE - 2.5

PLANWISE SHORTFALL IN ADDITIONAL INSTALLED CAPACITY

(MW)

Plan	Target	Achievement	Shortfall(%)
First Plan	1,300	1,100	15.4
Second Plan	3,500	2,250	35.7
Third Plan	7,040	4,520	35.8
Annual Plans	5,430	4,120	24.1
Fourth Plan	8,264	4,579	50.5
Fifth Plan	12,499	10,202	18.4
Annual Plan	2,945	1,799	38.9
Sixth Plan	19,666	14,226	27.7
Seventh Plan	22,245	21,402	3.8

Source: Current Energy Scene in India CMIE, May, 1992.

(ii) shift away from thermal to hydro-electric power,

(iii) renovation and modernisation of old power plants, enlargement of participation of centre in the power sector, reduction in power loss in transmission and distribution,

(iv) Strengthening of transmission and distribution system alongwith load dispatch and building up strong inter-regionalities with the ultimate aim of constructing national grid. The working group on power in 1991 envisaged a capacity addition of 36,646 MW for the eighth plan at an estimated cost of Rs. 1,27,000 crores. Later on due to financial constraint, it was revised downward to 31,115 MW with an outlay of Rs. 84,000 crores.

2.7 INVESTMENT IN POWER SECTOR

Power supply industry is a capital intensive industry and hence a large chunk of national resources are allocated in every plan to add to the installed generating capacity and to create the complementary transmission and distribution facilities. The outlay in power sector constitute an important overhead of the country engaged in the economic development power industry has always been on the priority in the Indian planning as it is clear from each five year plan's expenditure.

TABLE - 2.6

PLAN WISE INVESTMENT IN POWER SECTOR

Plan Period	Investment (Rs.in Crores)	As per centage of total plan outlays
First plan (1951-56)	260	13.3
Second plan (1956-61)	460	9.8
Third plan (1961-66)	1,252	14.6
Three Annual plans (1966-69)	1,213	18.3
Fourth plan (1969-74)	2,932	18.6
Fifth plan (1974-79)	7,400	18.8
Annual plan (1979-80)	2,240	18.4
Sixth plan (1980-85)	18,299	16.7
Seventh plan (1985-90)	34,273	19.0

Source: Economic Survey, Govt. of India, 1990-91.

Planned development of power supply industry was started in 1951, and since then bulk of the investment in the power sector has been in the public sector. The investment in power sector in First Five Year Plan was as much as Rs. 260 crores, out of a total plan investment of Rs. 1960 crores. A major portion of the power investment in this plan was for the development of multipurpose river valley development. The investment in

INVESTMENT IN POWER SECTOR DURING PLANS

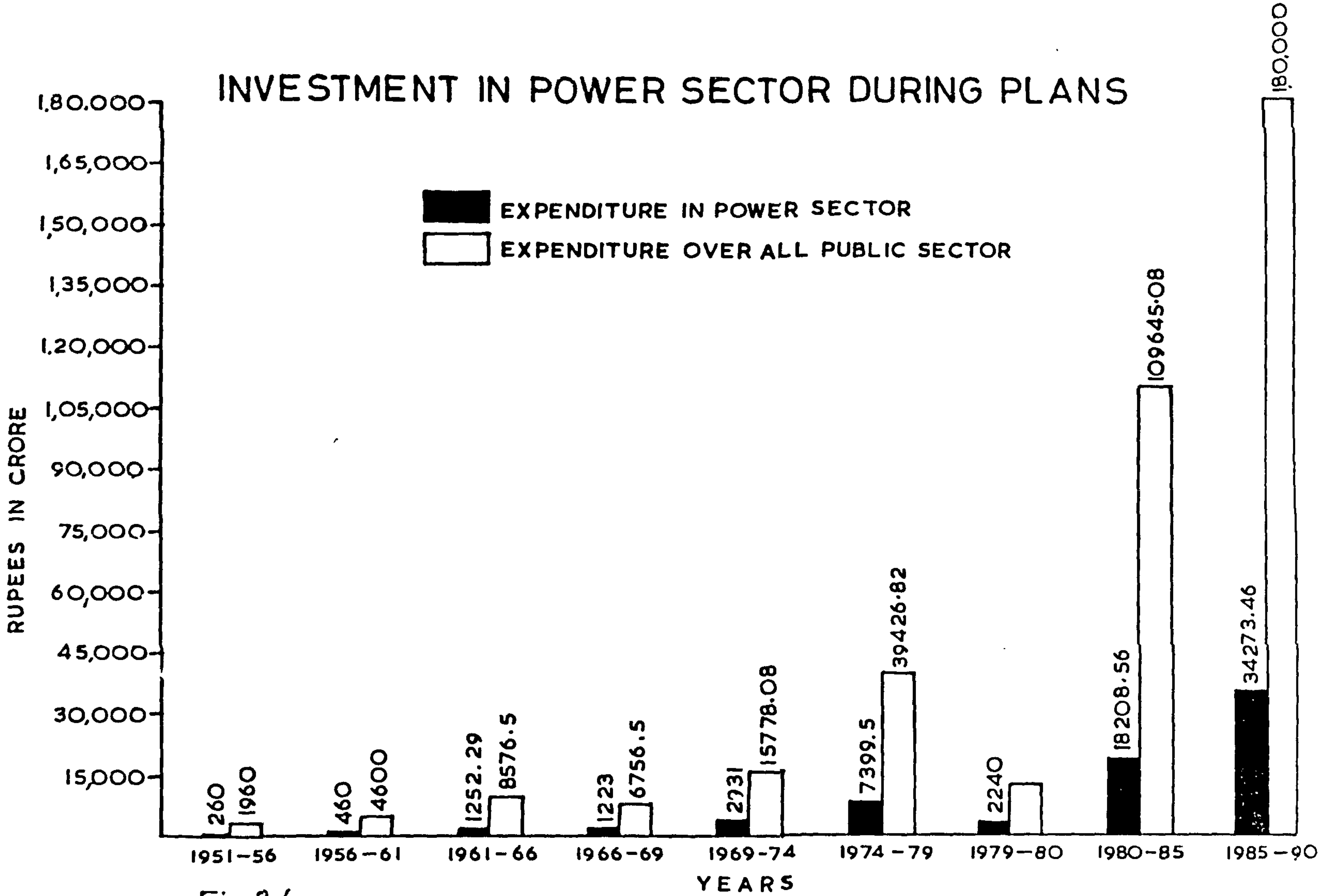


Fig. 2.4

the power sector has progressively increased with each successive plan, as it is clear from the table 2.6. Investment in power sector has gone up from Rs. 260 crores in the First Five Year Plan to Rs. 34,273 crores in the Seventh Five Year Plan indicating a significant growth. Similarly, the investment in power sector as percentage of the total plan expenditure increased from 13.3 per cent in the First Five Year Plan to 19.0 per cent in the Seventh Plan. Since the advent of the planning period, the Government has invested around 70.000 crores on power development by the end of the Seventh Plan period.

2.8 TRANSMISSION AND DISTRIBUTION

Transmission and distribution are important components of the power development in a country. With the increase in generation capacity, transmission and distribution networks have been expanded simultaneously throught out the country, covering thousands of kilometers. The development of high transmission voltage has been undertaken by State Electricity Boards during the five year plans. Transmission voltage has increased from 66 KV in 1900 to 132 KV in 1931 to 220 KV in 1954 to 400 KV in 1979.

In order to tide over power shortage and to make the most effective use of available power, it is imperative that the required transmission and distribution facilities are provided to transmit power with desirable levels and stability. The construction of transmission projects is also essential in the context of evacuation of power from generating stations to the beneficiary states. The plan outlays for transmission and distribution works have remained below the requirements due to resource constraints. The actual investments have been lower than the plan outlays.

TABLE - 2.7

PLAN OUTLAYS ON TRANSMISSION & DISTRIBUTION

(Rs. in Crores)

Plan Period	Plan Outlay	Actual Investment
First Plan	NA	132
Second Plan	117	115
Third Plan	327	301
Fourth Plan	722	802
Fifth Plan	1634	1299
Sixth Plan	5421	4706

Source: Report of the Committee of Power, Govt. of India, 1980.

The actual investment on transmission and distribution has always been less than planned outlays.

There has been inadequate investment in transmission and distribution system as compared to generation. There has been lack of proper integration of the transmission and distribution system with the generation plan, as a result of which in many cases generation capacity created can not be fully utilised.

2.9 TRANSMISSION AND DISTRIBUTION LOSSES

Transmission and distribution losses are computed as the difference between power delivered to the bus bar and the power sold, these figures include technical losses as well as theft of power.

In the process of generation and distribution of electrical energy, the loss component is a necessary evil. While losses cannot be completely eliminated in any system, they can be brought down to an optimum level. The magnitude of losses in any system depends largely on grid layout, pattern of loading and sales.

High transmission and distribution loss is another area of great concern to the Indian power sector. The average transmission and distribution losses on an all India basis are of the order of 22 to 23 per cent against 7 to 8 perc cent in developed countries like Japan, Canada U.S.A., France and USSR. These losses comprise of technical losses as well pilferages (Naidu. K.S.B:)

The transmission and distribution losses during the last decade are given in Table 2.8.

TABLE - 2.8

TRANSMISSION AND DISTRIBUTION LOSSES

(as percentage of electricity available)

Year	Transmission and Distribution Losses
1979-80	20.4
1980-81	20.6
1981-82	20.7
1982-83	21.1
1983-84	21.3
1984-85	21.5
1985-86	21.7
1986-87	21.5
1987-88	22.1
1988-89	22.3
1989-90	22.9
1990-91	22.9
1991-92	22.9

Source: Current Energy Scene in India, CMIE, May 1993.

Table 2.8 shows that transmission and distribution losses were 20.4 per cent in 1979-80, it went upto 22.9 per cent during 1989-90 and remained constant at 22.9 per cent till 1991-92. It is also clear from the table that there was no reduction in the average all India transmission and distribution losses over a decade.

2.10 HIGH VOLTAGE TRANSMISSION LINES

With the growth of central sector in generation of power, like large super thermal power stations by National Thermal Power Corporation and large source of hydel power by National hydro-electric power Corporation, large amount has to be transmitted to long distances. With Central participation in power sector high voltage transmission lines are increasing in circuit kilimeters.

TABLE - 2.9

MAJOR TRANSMISSION LINES 1980-81 to 1990-91

(Circuit Kms.)

Year	400KV	200KV
1980-81	223	3,476
1981-82	224	2,499
1982-83	1,126	3,878
1983-84	826	1,849
1984-85	1,500	3,565
1985-86	1,804	2,547
1986-87	3,433	2,154
1987-88	2,686	2,687
1988-89	3,134	2,998
1989-90	2,740	3,240
1990-91	4,725	2,489

Source: Current Energy Scene in India, CMIE, May, 1992.

Table 2.9 shows the construction of high voltage transmission lines of 400 KV and 220 KV from 1980-81 to 1990-91. The table reveals that high transmission lines of 400 KV have increased from 223 circuit Kms in 1980-81 to 4,725 circuit Kms in 1990-91.

2.11 POWER RESOURCES IN INDIA

There is a wide range of resources from which electric power can be generated. These resources include fossil fuels like coal, gas, petroleum products, nuclear materials as well as renewable sources of energy such as biomass, geothermal, hydel and solar source.

There are three main types of plants for electric power generation in the public sector in India, on the basis of major input resources i.e. hydel, thermal and nuclear.

2.11.1 THERMAL POWER RESOURCES

Though India ranks fifth in the production of coal in the world, it has reserves of only 201 tonnes of coal per person as compared to 13,747 tonnes in United States of America, and 1,060 tonnes in China. The known reserves of coal in India constitute only 0.8 per cent of the total world coal resources. While the total estimated resources of coal in India are 1,48,791 million tonnes, the mineable reserves may amount to about 60,000 million tonnes. Based on the demand projections upto the turn of the century and assuming an annual growth of 4 per cent in coal consumption thereafter these resources would be sufficient for about 130 years.

2.11.2 HYDRO POWER RESOURCES

The central Electricity Authority has made a systematic re-assessment of hydro electric resources of the country. The estimated annual energy potential is placed at 472.15 billion Kwh units which is equivalent to 89,830 MW at 60 per cent load factors. Of this potential 49.67 billion Kwh units have already been developed and 26.96 billion Kwh units are under development. More than 80 per cent of hydro potential still remains unharnessed despite inherent advantages of hydro-electric power plants over thermal and nuclear plants.

2.11.3 NUCLEAR POWER RESOURCES

The uranium resources in India are estimated to be about 70,000 tonnes which is equivalent to about 1,900 million tonnes of coal. This resource alone will be equivalent to 120 billion tonnes of coal used in breeder reactors. The long range potential of nuclear energy in India depends on the development of thorium whose reserves exceed 3,60,000 tonnes. When used in breeder reactors, this resource would be equivalent to 600 billion tonnes of coal which is about five times the coal reserves of India.

SUMMARY

It is evident from the discussion in the present chapter that the electric power development is inevitable for increased industrial and agricultural productivity and overall economic growth of the country.

With every successive five year plan, installed capacity has increased, resulting in increase in generation of power as substantial resources have been earmarked for power development. Inspite of massive increase in generation capacity power supply falls short of demand due to increase in consumption of power from various sectors of the economy.

There is a wide range of resources from which availability of power can be increased. Therefore, composition of power divided into three sections namely hydro, thermal and nuclear deserves a thorough investigation. The growth of different types of power plants namely hydro, thermal and nuclear has been analysed in detail in the following chapters separately.

CHAPTER - III

HYDRO POWER IN INDIA

Hydro power is a very significant, primary and conventional energy source for generating electricity. Hydro power plants utilize a natural resource which is renewable and have a relatively long life.

Hydro power "accounts for 23 per cent of total power production in the world. (Landsberg) It can be obtained easily as it comes in mechanical form which does not need conversion. It is one of the earliest means of providing electricity. The use of waterwheels in ancient times to produce energy for various purposes is well known.

In this chapter an attempt has been made to study hydro power potential in India, electricity generation by hydro power plants, their performance, present status of these plants, their problems, and strategies.

3.1 PRODUCTION PROCESS

In hydro power plants electricity is generated through water. Water is collected in reservoir and a steady stream is regulated through a specially built dam.

This water is brought by pipes to a lower level, where it flows through turbines. This rotation in the turbine provides machanical energy which is converted into electrical energy in the generators.

3.2 WORLD'S HYDRO POWER POTENTIAL

There is immense potential of energy produced from hydro power. "The estimated maximum world wide production of water power is equivalent of about 3 million megawatts of installed electrical capacity equivalent to 3000 large nuclear power plants of which a little over 10 per cent has already been developed." (Landsberg).

The estimated probable potential which is technically and economically useable has been assessed as 10,000 Twh (Tera watt hours = 10^{12} units). About 48 per cent of this total belongs to the developing countries. In the year 1979 the total electricity generation was 7,400 Twh of which 1570 Twh was produced by hydro-power stations, 610 Twh by nuclear power stations, 5,210 Twh by conventional thermal stations and 10 Twh by geo-thermal stations.

'Developing countries have a large potential of hydro power, but only 10 per cent of hydro power potential has been developed. These countreis have made rapid progress since 1973 after the rise in oil prices. Despite the renewed interest shown, development of hydro power is uneven. While Latin America produces a large amount, Africa's production is around two per cent, most of it is coming from big hydro projects like Kariba in East Africa, Aswan in Egypt and Aknsombo in Ghana. China has large size hydro power stations on the one hand and at the other extreme it has a number of micro hydro power stations. The developing nations are exploiting only a minimum of their total potential.' (Energy options and policy Issues in developing countries, 1979).

3.3 HYDRO POWER IN INDIA

The river systems in India provide plenty of scope for large scale water management as they descend from their sources in mountains and hills and flow along the plains towards the sea.

3.3.1 PHYSIOGRAPHY AND RIVER SYSTEMS

India is endowed with towering mountain ranges, rolling hills, lofty plateaus and extensive plains criss-crossed by rivers affording scope for hydro generation. India can be classified into seven well defined regions physiographically:

(i) The Northern Mountains comprising the mighty Himalayan Ranges.

(ii) The Great Plains, traversed by the Indus and Ganga Brahmaputra river systems. As much as one third of this lies in the arid zone of western Rajasthan. The remaining areas is mostly fertile plains.

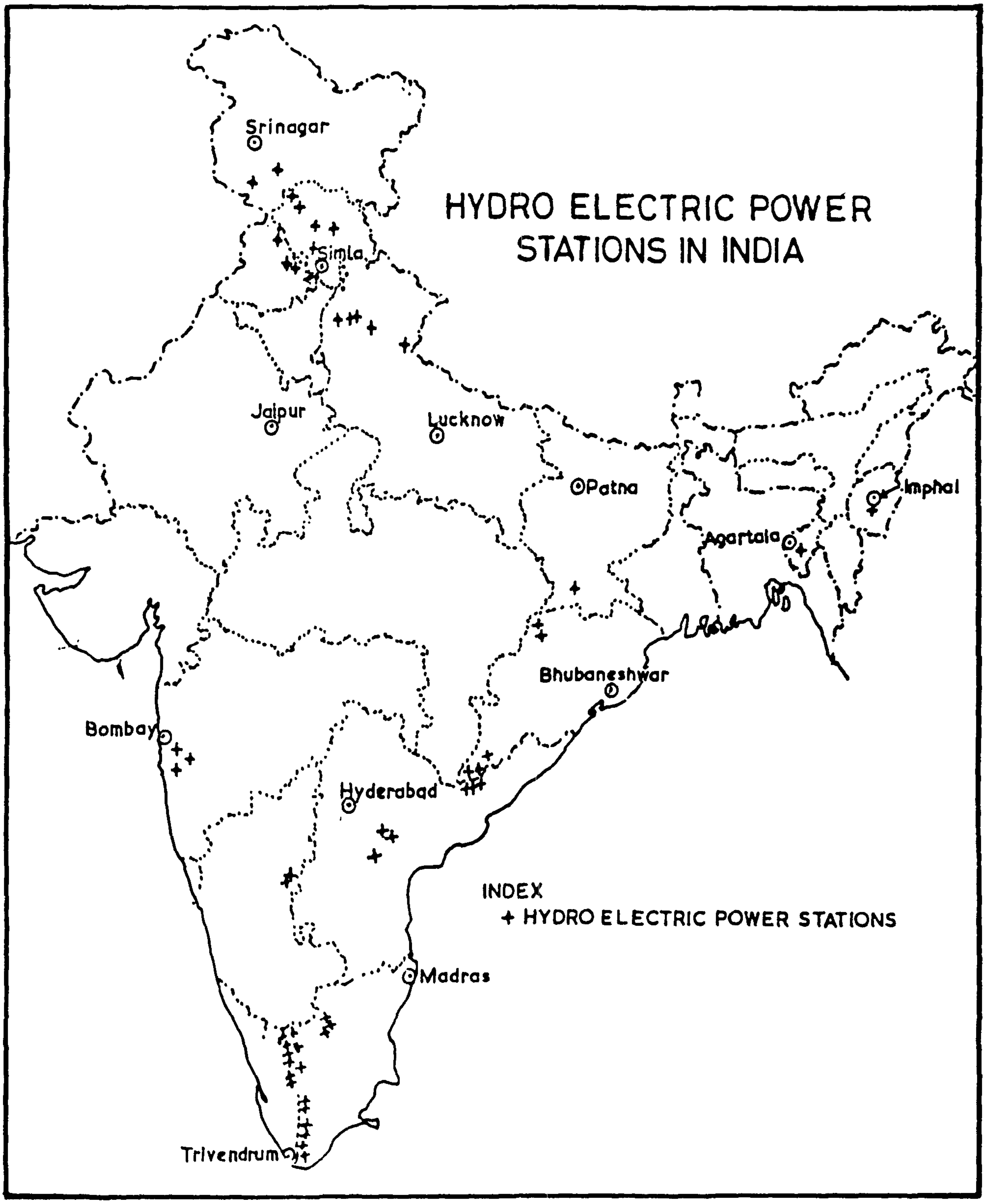
(iii) The Central Highlands, consisting of a wide belt of hills running west east starting from Aravalli Ranges in the west and terminating in a steep escarpment in the east.

(iv) The Peninsular Plateaus comprising of the Western Ghats, Eastern Ghats, north Decan plateau, South Decean plateau and Eastern plateau.

(v) The East Coast, a belt of land about 100-120 Km wide, bordering the Bay of Bengal and lying to the east of the Eastern Ghat.

(vi) The West Coast, a narrow belt of land of about 10-25 Km wide, bordering the Arabian Sea and lying to the west of the Western Ghats.

(vii) The island comprising the coral islands of Lakshadeep in Arabian sea and the Andaman and Nicobar Islands of the Bay of Bengal.


HYDRO ELECTRIC POWER
STATIONS IN INDIA
Srinagar
Simla
Jaipur
Lucknow
Patna
Imphal
Agartala
Bhubaneshwar
Bombay
Hyderabad
INDEX
+ HYDRO ELECTRIC POWER STATIONS
Madras
Trivendrum

Map. 3.1

3.3.2 RIVER BASINS

Rivers in India fall into four categories viz (a) Himalayan rivers (b) Deccan rivers (c) Coastal rivers and (d) Rivers of the inland drainage.

Himalayan rivers are generally snow fed and perennial besides getting copious supply during south west monsoons. The rivers in Deccan are mostly rain-fed especially during south-west monsoon carrying huge volume of water during rainy season and dwindling thereafter till the next monsoon. Many of these rivers are not perinnial. The coastal streams, especially on the west coast receive copious rainfall, command huge inflows from limited catchment areas, loses great heights within short length affording scope for development of hydro power.

Depending on the size of the catchment area, river basins are categorised as major, medium and minor basins. Major river basins of India are.

1. Indus
2. (a) Ganga (b) Brahmaputra (c) Barak
3. Sabarmati
4. Mahi
5. Narmada
6. Tapi

7. Brahmani
8. Mahanadi
9. Godavri
10. Krishna
11. Pennar
12. Cauvery

Besides, there are 22 west flowing and 24 east flowing medium river basins which along with major rivers make bulk contribution to hydro power development.

3.4 PROGRESS OF HYDRO POWER PLANTS

The first hydro electric power plant of a tiny 200 KW was set up in tea estates of Darjeeling in 1897. This small hydro electric plant established at the turn of the 19th century, marked the beginning of hydro-electric Power development in India. An installation of 4 KW to provide electricity to Kolar gold fields was commissioned in 1902 at Sivasamudram utilising the falls of Cauvery River. The capacity of this plant was gradually increased to 42 MW by the early thirties. Tata Power Company took up the development on three sites viz, Khopoli (72 MW), Bhivpuri (72 MW) Bhira (132 MW) on Western Ghats during the early part of twentieth century.

Inspite of an early start the progress of hydro power was very slow and the total installed capacity was only 570 MW by the end of 1951. The period immediately following the second worldwar was charcterised by several food shortage and a number of river valley projects oriented to food production were taken up. These projects were planned for multipurpose benefits and included hydro electric power generation as an important component. During the first three five year plans, five major multipurpose projects were set up. The most spectacular multi-purpose river valley project undertaken during this period was the Bhakra Nangal project in the North which was planned to irrigate land in Punjab, Haryana and Rajasthan and afford electricity generation with a total installed generating capacity of 1204 MW. Chambal Valley project was also set up in north, Hirakund and Damodar Valley in the East and Tungabhadra in the South. Besides these multipurpose projects, Several single purpose hydro electric projects like Rihand (in U.P. in the north), Kohna (in Maharashtra in the west), Balimela (in Orissa in the east), Uminan (in Meghalaya in the North-East) and Kundah (Tamil Nadu), Sharavati (Karnataka), Machkund and upper-Sileru (Andhra Pradesh) and Panniar Nerimangalam, Sabarigri (Kerala) all in south were also taken up for the development in the first three five year plan period. At the end of the Third Plan, the total installed capacity reached upto 5900 MW. During the Fourth Plan three hydro electric projects were commissioned namely, Salal of 345 MW in Jammu and Kashmir, Baira Siul in Himachal Pradesh of 180 MW and Lokta in Manipur of 105 MW. The need for central participation in hydro electric development was felt during the Fourth Plan period. The National Hydro Electric Power Corporation and North Eastern Electric Power Corporation were set up during the Fifth Plan to enable greater central participation, particularly in regard to major projects in remote areas, but the enmphasis shifted to thermal power projects. This shift in favour of thermal power has been countinuous. Towards the end of the Sixth Five Year Plan the capacities in hydel stood at 11,384 MW and in thermal 16,424 MW. The hydro-thermal mix which was 40:60 during the Fifth Five Year Plan came down 33.7:66.3 at the end of the Sixth Plan. The share of hydro power decreased mainly due to long gestation period and environmental considerations.

A study in the planning commission of the hydel projects commissioned in the Sixth Plan has revealed that the average gestation period of hydel project has increased. With a view to ensuring timely implementation of such projects in future the Seventh Five year plan emphasised on-

(a) better assessment of geological and environmental factors,

(b) strengthening of construction agencies in terms of equipment, organisation, technical know how and skilled manpower,

(c) development of optimal equipment, both qualitatively and quantitatively for various activites.

(d) arranging on lease basis large and costly machinery for construction agencies and regular flow of funds.

During the Seventh FYP 3827 MW of hydro installed capacity was added, but the share of hydro power declined to 20 per cent at the end of the Seventh Plan.

The Eight Five Year plan lays emphasis on new hydel projects, so that the share of hydel generation in the total installed generating capacity increases to a level of 40 per cent by the end of the Ninth Plan.

3.5 TOTAL HYDRO POTENTIAL IN INDIA

The Central Electricity Authority has made an extensive and systematic assessment of hydro potential of the country during 1978 to 80. The estimated annual energy potential is placed at 472.15 billion Kwh units which is equivalent to 84044 MW at 60 per cent load factor, which is said to be 2.9 per cent of worlds potential. Of this potential 49.67 billion Kwh units have already been developed and 26.96 billion Kwh units are under development. More than 80 per cent of hydro potential still remains unharnessed. The details of Central Electricity Authority's estimates of the hydro potential in the country's river systems are given in Table 3.I.

TABLE - 3.1

HYDRO ELECTRIC POTENTIAL OF RIVER SYSTEMS

(Basin Wise Distribution)

S. No.	Name of River system	No.of Basins studied	Firm Potential (MW)	Potential at 60% Load factor (MW)
1.	Great Indus	6	11992.8	19988.0
2.	Great Brahmaputra	9	20951.9	34919.8
3.	Ganga	10	6428.8	10714.8
4.	West flowing River of s. India	7	3689.0	6149.0
5.	East flowing of S. India	9	5719.0	9531.7
6.	Central India	8	1644.2	2740.3
Total		49	50426.1	84043.6

Source: Central Electricity Authority's Estimates of Hydro Potential in India.

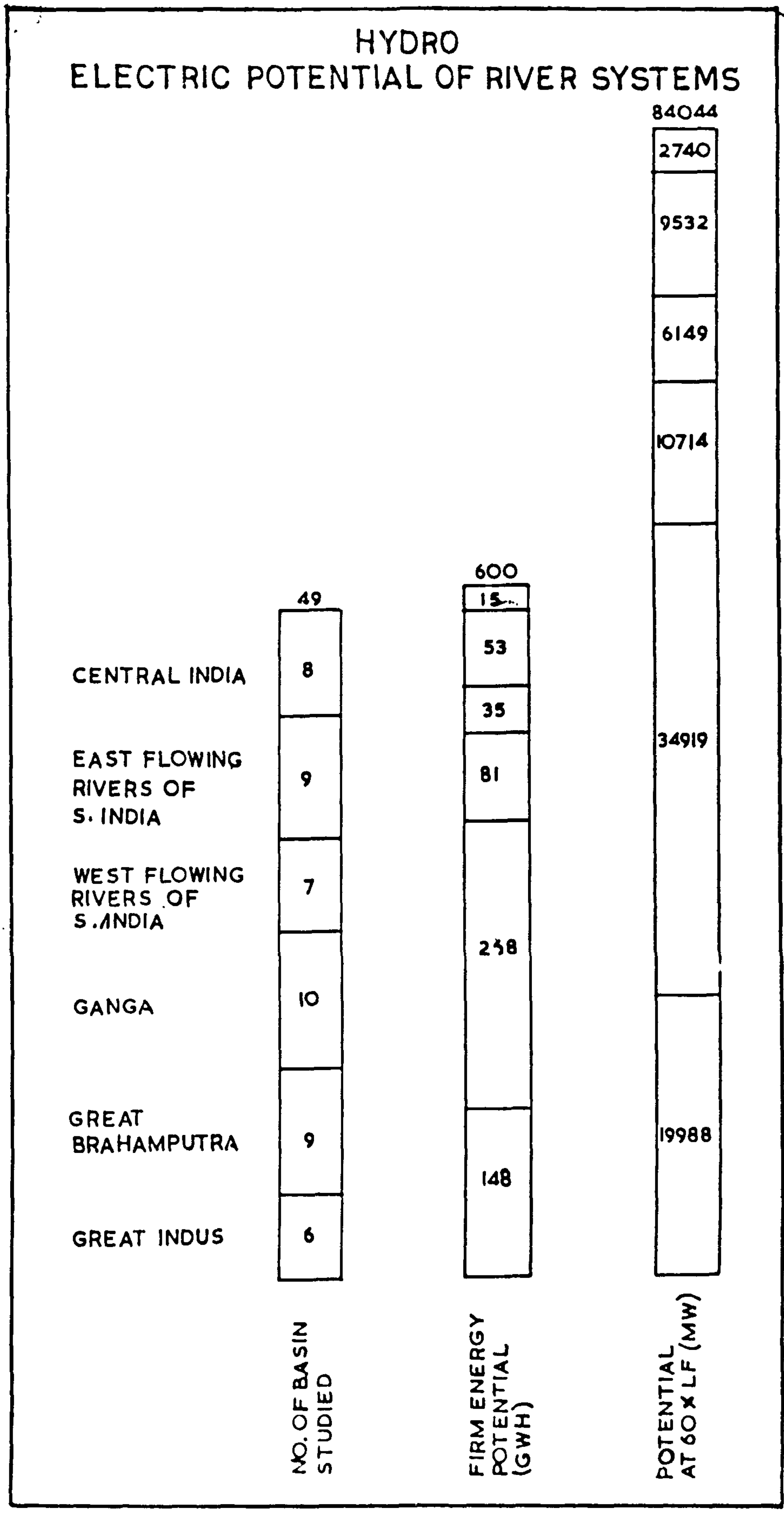

HYDRO
ELECTRIC POTENTIAL OF RIVER SYSTEMS
84044
2740
9532
6149
10714
34919
19988
600
15
53
35
81
258
148
49
8
9
7
10
9
6
CENTRAL INDIA
EAST FLOWING RIVERS OF S. INDIA
WEST FLOWING RIVERS OF S. INDIA
GANGA
GREAT BRAHAMPUTRA
GREAT INDUS
NO. OF BASIN STUDIED
FIRM ENERGY POTENTIAL (GWH)
POTENTIAL AT 60% LF (MW)

Fig. 3.1

The number of river basins, firm energy potential in Gwh and potential at 60 per cent load factor in (MW) of our country's river systems are pictorially depicted in figure 3.1.

The present status of development of hydro power in the country on the regional basis is given in Table 3.2. Table 3.2 shows progress achieved during different periods since 1947, capacity wise, and potential available for further development. It is clear from the table that bulk of hydro potential is yet to be harnessed in different areas of the country.

The table also shows that 78 per cent of hydro potential still remains undeveloped despite inherent advantages of hydro electric power plants over thermal and nuclear plants. Bulk of the undeveloped potential lies in the northern region in the Himalayan range and in the associated foot hills of the Indus, the Ganga and Brahmaputra basins. The sizeable untapped potential is also available in the peninsular river basins-Narmada, Mahanadi and Godavari basins.

The potential in MW available for future development in the country are shown in Fig. 3.2.

TABLE - 3.2

REGION-WISE STATUS OF HYDRO ELECTRIC POTENTIAL DEVELOPMENT

	North	West	South	East	North East	All India
Total Potential at 60% L.F.(MW)	30155	5679	1073	5590	31857	84044
% of total potential of the country	36	7	13	6	38	100
Potential developed in (MW)	6160	3099	6365	1596	599	18818
% Potential developed	20.4	54.5	59.2	28.5	1.9	21.2
Potential available for future development (MW) 60% L.F.	23955	2580	4398	3994	31258	66226
% Potential available for further development	79.6	45.5	40.8	71.5	98.1	78.8

Source: Central Electricity Authority.

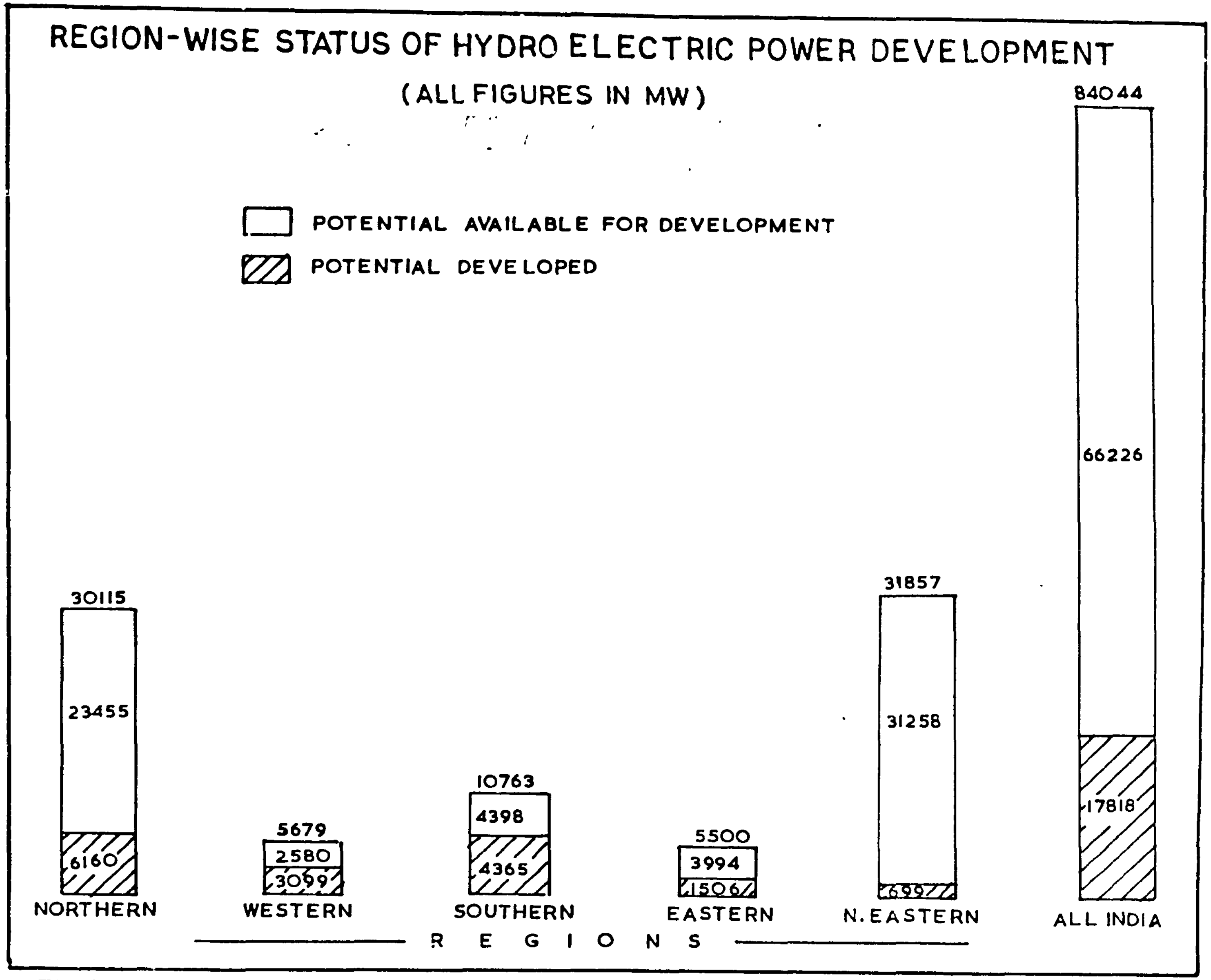

REGION-WISE STATUS OF HYDRO ELECTRIC POWER DEVELOPMENT
(ALL FIGURES IN MW)
POTENTIAL AVAILABLE FOR DEVELOPMENT
POTENTIAL DEVELOPED
30115
23455
6160
5679
2580
3099
10763
4398
4365
5500
3994
1506
31857
31258
699
84044
66226
17818
NORTHERN
WESTERN
SOUTHERN
EASTERN
N. EASTERN
ALL INDIA
R E G I O N S

Fig.3.2

3.6 INSTALLED CAPACITY AND POWER GENERATION OF HYDRO PLANTS

The progress of installed capacity and power generation of hydro plants and their share in overall capacity and power generation are presented in Table 3.3.

TABLE - 3.3

INSTALLED CAPACITY AND POWER GENERATION OF HYDROPOWER PLANTS

Year	Installed capacity (MW)	Share of hydro IC to the total installed capacity (in %)	Generation in Hydro power (in MU)	Share of hydro power in overall power generation (%)
1951	575	31.3	2860	48.8
1956	1061	36.7	4295	44.5
1961-62	2419	46.3	9814	49.9
1966-67	4757	47.1	16734	46.0
1971-74	6612	43.3	28024	40.0
1976-77	9025	42.0	34836	39.4
1981-82	12173	37.6	49565	40.6
1986-87	16195	32.8	53840	28.6
1987-88	17265	31.8	47444	23.4
1988-89	17798	30.1	57867	26.1
1989-90	18307	28.7	62054	25.2

Source: Report, Central Board of Irrigation and Power, 1990-91, New Delhi.

Table 3.3 indicates that total installed capacity of hydro stations has increased to 18307 MW in 1989-90 recording an increase of 36 times. The total energy generation which stood at 2860 million units in 1951 rose to 62054 million units in 1989-90, an increase of about 27 times. But the share of hydro installed capacity to total installed capacity has been declining.

The pace of hydro electric development has slowed down after 1970 as more emphasis was laid on thermal power projects. Its share has dropped to 32.8 per cent 1986-87.

3.7 DECLINE IN HYDRO POWER DEVELOPMENT

The growth of hydro capacity in the country has been very satisfactory during the period upto the end of Third Five Year Plan (1969). The share of hydro power in the overall installed capacity of power plant in the country during this period increased from 33 per cent in 1951 to 46 per cent in 1969. The average annual growth rate of installed capacity of hydro power plant during this period has been at about 14 per cent.

It was during the Fourth Plan and beyond that more emphasis was placed on thermal development due to various reasons. Consequently growth of hydel power was hampered and its share in the overall installed capacity declined rapidly from 46 per cent in 1969-70 to 29.8 per cent in

1989-90. The annual rate of growth in installed capacity of hydro power plant during the period 1973-74 to 1989-90 came down to as low as 6 per cent only as compared to the earlier growth rate of 14 per cent.

The pace of hydro electric development has slowed down inspite of its intrinsic merits.

Sambamurti (1983) has pointed out that in Indian conditions hydro power is the most economical source of power generation. He has further pointed out that there is a need for accelerating hydro development. Hydro projects of the storage type should be given the highest priority in view of the support they provide for stable system operation. Special policy measures are necessary to overcome the constraints slowing down hydro development at present. This includes finding adequate funds for investment in the long term projects and evolving techniques of accelrating construction at sites remotely located and presenting geo-technical complexities.

3.8 PERCENTAGE SHARE OF HYDRO CAPACITY

The percentage shares of hydro capacity in the Hydro-Thermal mix as it existed during various plans are depicted pictorially in the figure 3.3.

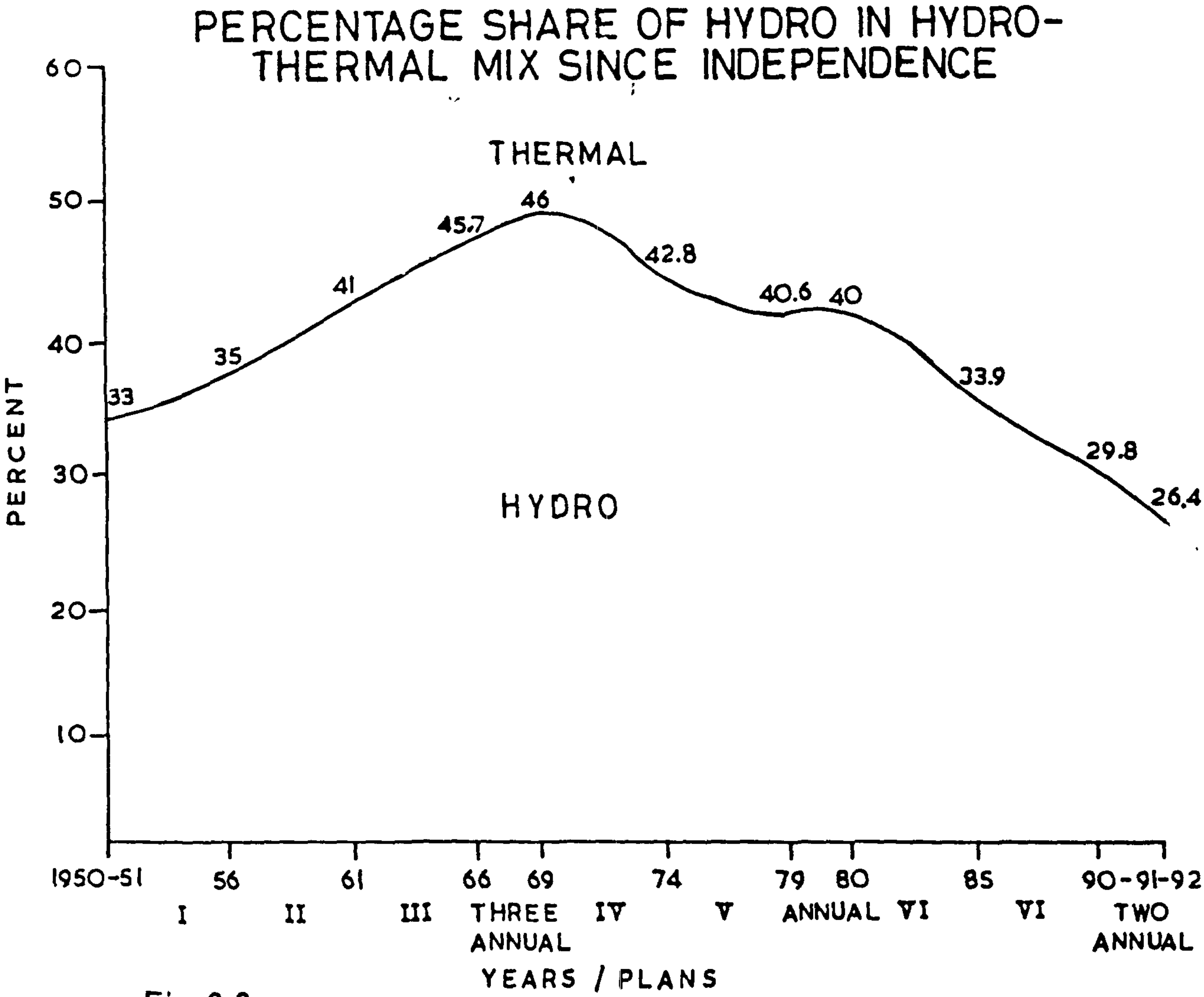

PERCENTAGE SHARE OF HYDRO IN HYDRO-THERMAL MIX SINCE INDEPENDENCE
THERMAL
HYDRO
PERCENT
60
50
40
30
20
10
33
35
41
45.7
46
42.8
40.6
40
33.9
29.8
26.4
1950-51
56
61
66
69
74
79
80
85
90-91-92
I
II
III
THREE ANNUAL
IV
V
ANNUAL
VI
VI
TWO ANNUAL
YEARS / PLANS

Fig. 3.3

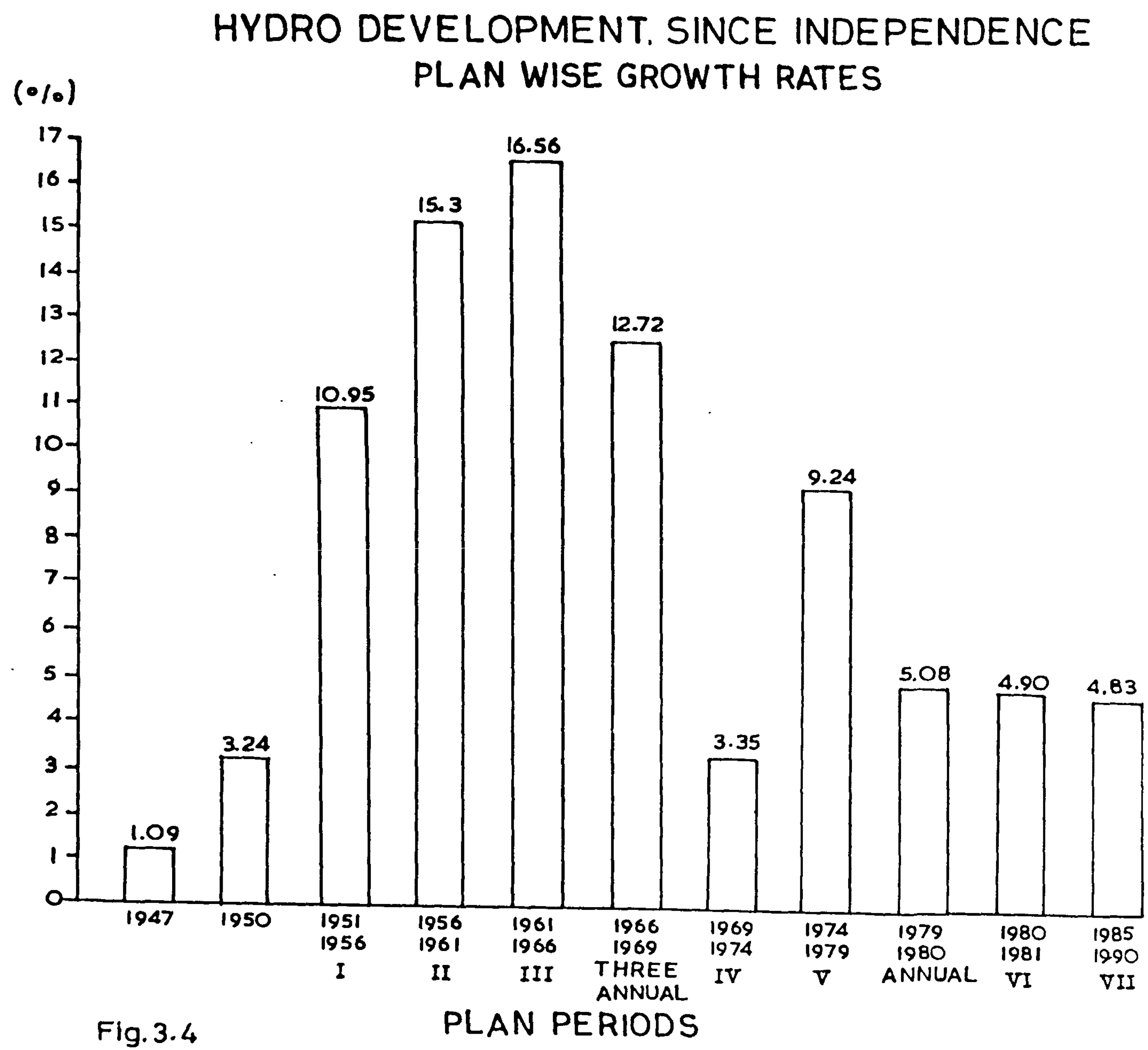

HYDRO DEVELOPMENT, SINCE INDEPENDENCE
PLAN WISE GROWTH RATES
(%)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1.09
3.24
10.95
15.3
16.56
12.72
3.35
9.24
5.08
4.90
4.83
1947
1950
1951 1956 I
1956 1961 II
1961 1966 III
1966 1969 THREE ANNUAL
1969 1974 IV
1974 1979 V
1979 1980 ANNUAL
1980 1981 VI
1985 1990 VII
PLAN PERIODS

Fig. 3.4

The figure shows that Hydro Thermal mix was quite satisfactory (40:60) till the end of the Fifth Plan. It declined considerably during the Sixth and Seventh Plans creating an imbalance in the hydro thermal mix. The share of hydro electric power has slowed down considerably during the Sixth and the Seventh Plans due to constraints of financial resources, environmental consideration as well as problems in acquisition of forest land.

3.9 PLAN-WISE GROWTH RATES OF HYDRO POWER

The plan-wise annual percentage growth rates of hydro capacity is indicated in figure 3.4. The figure shows that growth rate was maximum during the third Five Year Plan and lowest 2.43 per cent during 1990-91. It remained constant between 4 per cent from 1979-80 to 1990-91 due to financial constraints and environmental problems.

3.10 CONSTRAINTS AND STRATEGIES

Even though the hydro power in general is the least cost power supply option and inspite of the recommendations of various committees, the pace of hydro power development has not gained momentum and has instead slowed down considerably after mid Sixties. There are several factors constraining the development of hydro power in the country.

3.10.1 FINANCIAL CONSTRAINTS

Lack of adequate financial resources has been one major constraint in the matter of power development, but it had the severest effect on the hydro power development in the country.

Since the short term solutions to mitigate the immediate power shortage have been getting priority over long-term solution, therefore, thermal projects having substantially shorter gestation periods have been getting pushed up for early gains, leading to the deferring of benefits from hydro schemes and power development has moved along sub-optimal course. A decision is required to strike a balance between short term and long term solutions so that the power development could move towards optimal course.

In order to finance the hydro power schemes it is necessary that the allocations be kept reserved for the particular schemes. In the past it has been experienced that since the allocation for the multipurpose schemes are given by the irrigation and energy sectors the hydro, including multipurpose schemes remain at the mercy of these two sectors. For each of the sector the priority shifts towards their own singular schemes and thus the multipurpose scheme suffers, there are slippages and cost over runs.

Since heavy investments are required for the hydro schemes it may not be possible to fund these schemes from the State's own resources, then it would be necessary to get financial aid from outside. Power Finance Corporation may also provide necessary funding for the development of important hydro projects, which are languishing in addition to its transmission and distribution systems.

3.10.2 ENVIRONMENTAL PROBLEMS

In India very few hydro power project have been abandoned on account of considerations of adverse impact on the environment. Almost all the power projects have been given environmental clearances, but after a lapse of considerable time which has resulted in substantial time and cost over-runs. These delays in environment and forest clearance have been mainly on account of various procedural constraints and delays in necessary studies required to be conducted for making an overall assessment of impact of the concerned power project on 'the environment'. To reduce time and cost over-run due to delayed environment and forest clearance, procedural bottlenecks must be identified and clearance processes must be streamlined. The Department of Environment may consider giving principle clearance to hydro power projects based on minimum required information, prime facie satisfying that there are not going to be major adverse impacts on the environment necessitating final rejection of the complete schemes.

3.10.3 ORGANISATIONAL PROBLEMS

There is no uniformity in the functional distribution and the organisational set up for hydro electric development among the various States. While in some States, the responsibility is vested with the State Electricity Boards (or Power Corporation), in most of the States, the responsibility is either divided between the State Electricity Boards and the Irrigation Department (or organisation responsible for water resources development) or it is almost entirely with Government or divided between the Irrigation Department and the departmental organisation responsible for hydro-electric power development.

An analysis of hydro-electric power development in the past shows that in the States where the responsibility for hydro electric development is vested with the State Electricity Boards, the progress has been faster. There are several States/Union Territories where organisation for hydro-electric development exists only in a rudimentary form.

Large number of hydro sites, yet to be developed lie in Jammu & Kashmir, Himachal Pradesh and Uttar Pradesh in Northern Region, Madhya Pradesh in Western Region, Andhra Pradesh, Karnataka and Kerala in the Southern Region, Orissa, Bihar and West Bengal in the Eastern Region and Arunachal Pradesh and Meghalaya in the North Eastern Region. Uttar Pradesh, Andhra Pradesh, Karnataka, Kerala, and Orissa have considerable experience in hydro electric development and from the point of view of expertise, the organisations in these States do not pose any serious problem. Jammu & Kashmir, Himachal Pradesh, Bihar, Meghalaya, and Arunachal Pradesh have limited experience in hydro-electric development, limited to smaller projects. It would be necessary for the Government to review the organisational structures in these States and reorganise them to make functionally effective.

3.10.4 INTER-STATE DISPUTES

Sharing of water resources of inter state river systems is a complex as well as political issue. Differences and disputes between riparian States have inhibited and delayed hydro-development in some of our major river systems.

The Inter-State disputes in the Narmada, the Godavari and the Krishana river basins might be partly responsible for Madhya Pradesh, Maharashtra and Andhra Pradesh turning away from hydro projects after pioneering developments in the chambal, the koyna, the sileru and the Tunga-bhadra valleys. The Tribunal awards on sharing of water resources in the Narmada, the Godavari and the krishana river basins in the last few years have set at rest the competing claims of the reparian States for shares and released a large quantum of hydro-electric potential for development. Most of the undeveloped sites in these river systems require Inter-State cooperation. Such co-operation would involve participation, in completing investigation and project report preparation, project organisation and management and financing. There is also need for effective coordination between organisations responsible for irrigation and power development within each State. Inter-State differences and disputes are delaying important hydro-electric projects in the Cauvery and the Yamuna River Basins. Settlement of these differences would have to be followed by active cooperation between States in which the potential sites are located for rapid development of the potential in these river basins.

3.10.5 TECHNOLOGICAL UPGRADATION AND GESTATION PERIOD

The gestation period of hydel projects depends on several factors, viz, geological conditions at site, features of the project and the method of construction, etc. Since most of the sites are now located in remote and difficult areas where infrastructural facilities for transportation and communications are lacking, the same is resulting in prolonged period of initial site preparation.

To speed up the construction activities of hydro project, Government of India should advise State Governments. Central/State organisations responsible for developing hydro-electric projects to take up site development including site clearance, levelling, roads formation, colony construction and providing of telecommunication links as soon as the schemes are techno-economically cleared by Central Electricity Authority. The project implementing authorities may take up these works as advance action without awaiting final sanction by the government. Government of India may take appropriate action in making available the required funds, as soon as Central Electricity Authority accords their techno-economic clearance. It may also be desirable that the project implementation agencies like State Electricity Boards/organisations are advised by the Government of India to ensure that the prospective contractors must be competent, equiped both with modern construction equipment latest technology and follow the modern project management techniques to help in bringing up the projects at a faster pace.

It would also be helpful if the Power Finance Corporation could either provide funds as loan assistance to the project authorities to buy the required modern and special construction equipment and tools as found necessary for speeding up the construction activities. Alternatively, the Power Finance Corporation may purchase such modern construction equipments and lease them to project authorities on commercial lines.

3.10.6 PROBLEMS RELATING TO LAND ACQUISITION

The land required for the projects is being acquired under land Acquisition Act 1894 through previous consent of the appropriate Government and by an award of the respective District Collector after observing the procedure Laid down in the Act. The minimum time required for taking possession of the land is about an year, though in practice it takes about 2 to 3 years depending up on the efficiency and co-operation of the Civil Authorities.

The alternative method of acquiring land isthrough private negotiations by committee constituted for this purpose, which may generally include a representative of the Revenue Authorities to help in identification of the legal owners of the land. In this case, the time of acquisition of land is drastically cut down and it is possible to get possession of the land within 3 to 6 months time. The associated problems with this method are that the land thus acquired is not incumbrance free, possible litigations may arise when some of the land owners do not agree to execute the sales deed even after their signing the agreements. Also the rate to be paid is much higher than the rate that is applicable under the land Acquisition Act for land so acquired. Under these conditions, the Government should bring out adequate amendments in the land Acquisition Act and procedures to speed up the process of land acquisition for hydro projects treating the hydro resources as national assests with a view to bring up hydro electric projects at a much faster pace.

3.10.7 GEO-POLITICAL FACTORS

The hydro resources are unevenly distributed among the political divisions in the country. Most of the untapped hydro potential lies mainly in the States which do not have either the demand for or resources for their development and this has been a major inhibiting factor in the area of hydro power development. Besides this, uncertainities in constructing civil works in difficult geological terrains and several administrative and managerial problems associated with specific hydro projects have also been contributing to the slow pace of hydro power development in the country.

3.11 INDIGENEOUS MANUFACTURING OF HYDRO POWER EQUIPMENTS

A programme of indigenous manufacturing of heavy electrical power equipments was initiated during the fifties, when recognising the need for manufacture of turbines and generating units indigenously the Government of india had set up Bharat Heavy Electricals Ltd. in Bhopal to facilitate speedy development of power. This was followed by three heavy electrical factories with facilities for manufacture of steam and hydro generating units transformers and switchgear at Hardwar, Hyderabad and Tiruchi. Bharat Heavy Electricals Ltd. has been been supplying most of the equipments required for hydroelectric stations. The first hydro generation equipment indigenously manufactured went into operation in the year 1970-71. This was immediately followed by another unit at Bassi (15 MW) in Himachal Pradesh during the same year. The country is now in a position to manufacture the whole range of hydro power equipments at international standards.

TABLE - 3.4

INDIGENOUS HYDRO-POWER GENERATION EQUIPMENT

(The capacities commissioned from seventiers onwards)

Year	Indigenous Equipments(MW)
1970-71	96
1971-72	63
1972-73	15
1973-74	26.3
1974-75	286.3
1975-76	720
1976-77	412
1977-78	755
1978-79	725
1979-80	394
1980-81	304
1981-82	380
1982-83	840
1983-84	760
1984-85	400
1985-86	742.5
1986-87	548.5
1987-88	958.45

Source: Central Electricity Authority.

Table 3.4 gives the trends in the indigenous manufacture and supply of power equipments during the period 1970-71 to 1987-88. The largest unit in operation at present is 165 MW at Dehar Power Station Beas Project.

Some of the projects under construction like Sardar Sarovar, Tehri Hydro Electric Project and Nathpa Jhakri Hydro electric project will have units of capacity varying from 200 MW to 250 each, which Bharat Heavy Electric Limited, (BHEL) will be supplying.

3.12 NEED FOR ACCELERATION HYDRO PROJECT

Hydro power is the cheapest among various available source of power supply because in case of hydel power, the fuel cost component is nil as compared to other conventional options of power supply namely, coal and gas, thermal and nuclear.

Hydro electric power plants utilize natural resource which are renewable and the production of power does not consume water. The raw material, i.e. water can be put to other uses like irrigation etc. after it has ben put to generation of power. Unlike coal it does not involve transportation of raw materials by rail. Thus the effect of inflation on the raw material and transport is not reflected in the cost of generation.

Hydro-power projects have a relatively longer life and low depreciation, unforseen breakdowns in hydro projects are less frequent and overhaul and maintenance require plant shut downs of very short durations. They are non pollutable. Their operation and maintenance costs are low compared to other sources of generation. Their ability for quick start and stop operation and varying their outputs make them eminently suitable for meeting peak loads. The hydro power projects which are based on reservoirs have peaking capacities. They have the unique advantage of increasing the capacity of peaking manifold by having pumped storage schemes.

Due to difference in peaking capabilities of hydro and thermal plants, less capacity of hydro projects is needed as compared to thermal plants when both are called to meet the system peak load. The study in Central Electricity Authority indicates that reduction of 1 MW hydro capacity in the optimal power plan, on an average, would require addition of 1.6 MW of thermal power projects which would increase the investment accordingly.

Besides, hydropower fills in the lacuna found in uneven availability and production of energy. The main coal producing states of Bihar and West Bengal are not well favoured with respect to hydro resources. On the other hand, a number of States in the South and North West, which have no coal resources and are remote from the coal producing areas are well endowed with hydro-electric potential such as Himachal Pradesh, Uttar Pradesh and North Eastern Region.

Hydro power needs to be harnessed to the maximum feasible limit as it would result in reduced environmental pollution and conservation of non-renewable fossil fuel reserves.

SUMMARY

Thus it is clear from the discussion in the present chapter that hydro power is an important, primary and con-ventional source of electricity. Hydro power plants utilize a natural resource which is renewable and have a relatively long life. The river systems in India provide plenty of scope for large scale hydro development.

The growth of hydro power capacity in the country has been very satisfactory during the period upto the end of the Third Five Year Plan. It was during the Fourth Plan and beyond that more emphasis was placed on thermal development, consequently growth of hydel power was hampered and its share in the overall installed capacity declined. The share of hydro capacity declined considerably during the Sixth Five Year plan and the Seventh Five Year Plan creating an imbalance in the hydro-thermal mix. The hydro-thermal mix which was 40:60 during the Fifth Five Year Plan came down to 33.7:66.3 at the end of the Sixth Five Year Plan. The share of hydro electric power has slowed down considerably during the Sixth Five Year Plan and Seventh Five Year Plan due to constraints of financial resources, environmental considerations as well as problems in acquisition of forest land .

Hydro power needs to be harnessed to the maximum possible limit, as it is the cheapest source of power generation among various available sources of power supply. it utilizes natural resource i.e. water as a result fuel cost component is nil as compared to other conventional options of power supply namely thermal and nuclear.

To meet the growing demand of power, the generation of electricity through thermal power is very essential. Thermal power is playing an important role in power sector. The study of thermal power development has been taken up in the next chapter.

CHAPTER - IV

THERMAL POWER IN INDIA

Thermal power has the maximum share in the total power generation in India. Installed capacity of thermal power has gone up to about 65,000 MW from meager installed capacity of about 2,300 MW at the time of Independence registering a phenomenal growth. Many thermal power stations have been commissioned since early sixties. The phenomenal growth of thermal power generation may be due to their low gestation period, flexibility of site selection, ease of augmentation of existing facilities, etc.

Thermal power dominates the Indian power scene as it constitutes over 67 per cent of total installed capacity and contributes about 69.8 per cent of total power generation. It has been argued that thermal power will continue to play an important role in the power development scenario in India for a long time to come. In this chapter an attempt has been made to analyse the production process, performance and plant load factor of thermal power plants in India. Problems of thermal power have also been underlined.

4.1 PRODUCTION PROCESS

Electric power in thermal plants is produced by burning coal (or lignite) and gas (or oil). A modern thermal plant is a highly complex marvel of engineering, built essentially of structural steel besides using several special grades, for critical and vital applications.

Important processes and operations occuring in a power stations involve combustion of coal, transfer of its heat energy to water and steam in such a manner so as to obtain high thermal efficiency in the conversion process and use of superheated steam at high pressure to drive the turbine in order to cause motion of the roter at high revolutionary speed inside a generator resulting finally in the generation of electricity. The output of electricity is itself the net outcome of a number of different operations Simultaneously carried out; some of the important ones are-

(i) regular receipt of coal from mines of consistent quality, often involving transportation over long distances,

(ii) crushing and grinding/milling of coal to a size mix acceptable for the pulverised fuel firing system.

(iii) pneumatic transportation of pulverised coal in pipes suitably lined to with-stand erosion to the burners with preheated air,

(iv) regular supply of demineralised water, suitably treated to remove dissolved oxygen and carbon dioxide and suitably chemically treated for the purpose of steam rising,

(v) conversion of water into high pressure, high temperature and high quality steam,

(vi) transportation of the superheated steam under high pressure from the boiler to the turbine to cause high speed rotational movement of the generator rotor, to finally generate electricity.

Major inputs in thermal power plants are coal, air and water. Thermal energy of coal, released through its combustion has to be continuously, without interruption or obstruction, transferred to water and steam through processes involving radiation and convection. This is done by making the water and later steam flow under high pressure through pipes and tubes made of special steels which can stand high temperatures without loss of strength, even on continued exposure for prolonged periods of several years, estimated for the prupose of design as any thing between 15-30 years.

A thermal power station will be able to generate electric power to its rated capacity only, if all its constituent sub-units namely, water treatment plant, pulverisation and firing system, the boiler itself, turbine, generator, condensor and auxiliary system such as pumps, fans etc. operate cooperatively. While any single rupture any where in its vast network of tubes will bring the giant unit to a grinding halt. Troubles any where can make the boiler only partially available. Partial availability means capacity is not utilized fully which burdens the whole system with demand for additional capacity and loss of revenue.

4.2 RESOURCES FOR THERMAL POWER IN INDIA

Coal resources are very versatile and have a wide range of potential use in all forms of its availability. It is relatively an important resource and could be an important substitute for scarce and fast depleting oil and atomic minerals. Coal has been bearing the main burden of power needs of the country.

India's coal resources have been assessed at 1 per cent of the world's total coal reserves. The Energy Policy Committee (1980) has assessed that the available coal reserves of India would be adequate to last for about hundred years, assuming that the annual coal production would reach 417 million tonnes by the year 2000 and continue to rise at a slightly Slower pace, thereafter. This estimate is based on reserve of coal seams of thickness of 1.2 m and above and up to a depth of 600 m with 50 per cent recovery rate.

4.2.1 COAL RESERVES

The main reserves of coal in India are concentrated in the north-eastern part in the states of West Bengal, Bihar, Assam, Orissa, in central part in Madhya Pradesh and Maharashtra and in the South, Andhra Pradesh.

The estimates of total reserves are given in table 4.1.

TABLE - 4.1

RESERVES OF COAL IN INDIA

(in million tonnes)

Non-coking coal	Proved	Indicated	Inferred	Total
in Gondwana	44,764	71,211	47,423	1,63,398
in tertiary	257	149	458	864
Total non-coking	45,021	71,360	47,881	1,64,262
Total coking	13,765	12,573	1,471	27,809
Total coal	58,787	83,933	49,352	1,92,062

Source: New Coal Wing, Geological Survey of India, 1991.

The estimate of total reserves of non-coking coal place of inferred reserves at 47,881 million tonnes while proved and indicated as 45021 and 71360 million tonnes respectively. The total reserve of coking coal is 27,809 million tonnes whereas non-coking coal is 1,64,262 million tonnes. The biggest deposit is in Jharia in Bihar while the Raniganj field occupies the second position. Together these two fields contribute about 40 per cent of the explored coal deposit.

The reserve of non-coking coal is more significant from the point of thermal power generation. This is because thermal power generation is met through non-coking coal. More than 85 per cent of coking coal is found in Bihar and including West Bengal the percentage of proved reserve goes to more than 95 per cent and including Madhya Pradesh, it is 100 per cent. The concentration of the reserves of coal in specific regions raises the problem of its transportation.

4.2.2 COAL PRODUCTION

Coal production in India has steadily increased with the rapid pace of the industrial expansion particularly iron and steel industry and thermal power plants.

TABLE - 4.2

DEMAND AND PRODUCTION OF COAL (in Million tonnes)

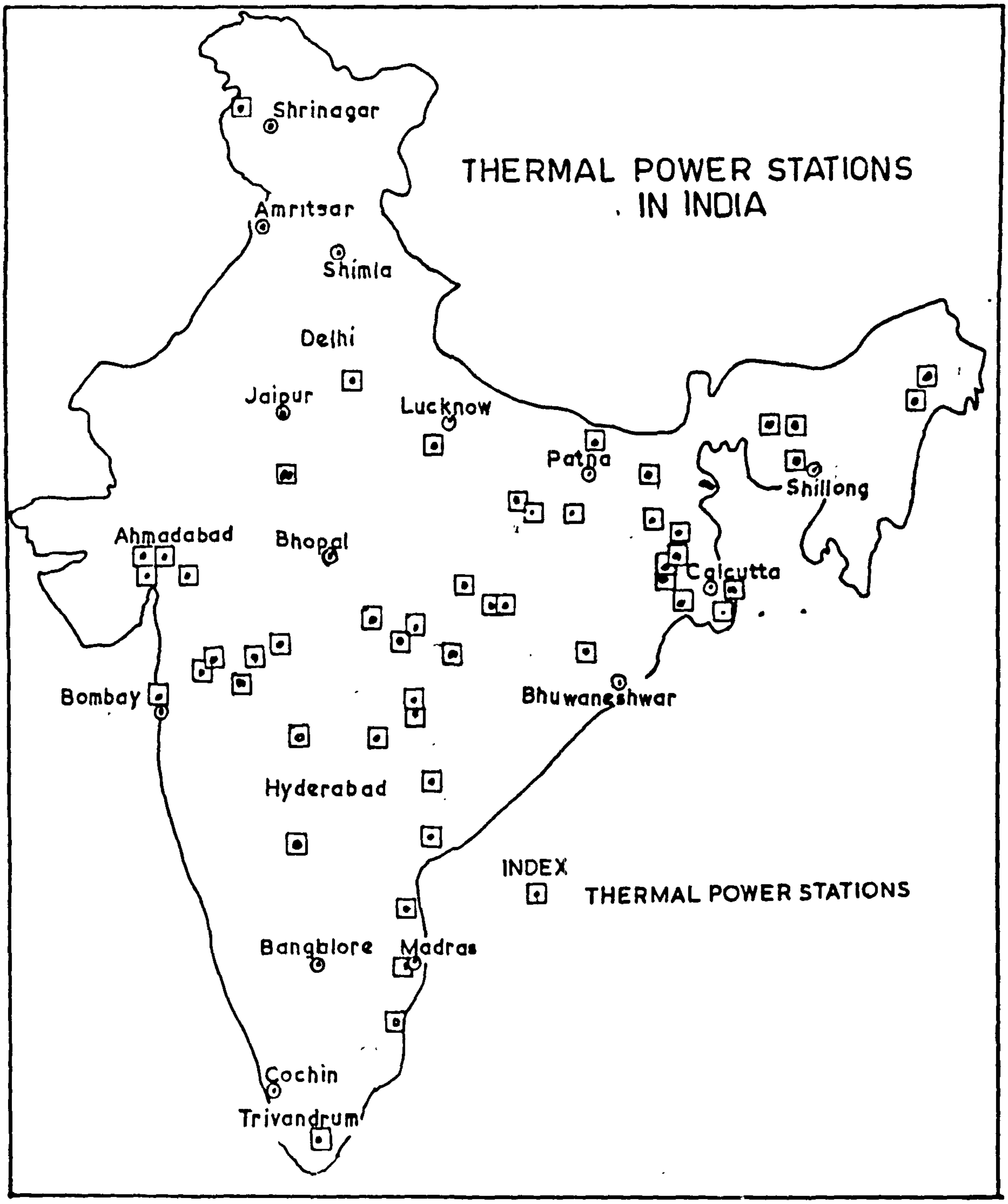
Period	Target	Production	Demand
First Plan	39.00	38.30	41.60
Second Plan	60	57.67	-
Third Plan	97.30	67.73	60.10
Fourth Plan	93.50	78.17	90.00
Fifth Plan	135.00	101.95	165.00
Sixth Plan	165.00	147.41	143.00
Seventh Plan	220.00	202.71	246.00
Eight Plan	318.00	-	326.00
Ninth Plan	410.00	-	417.00

Source: Annual Report of Department of Coal (1986-87).

The demand and production of coal is given in table 4.2. The table shows that output of coal increased from 38 million tonnes in the First Plan to about 203 million tonnes at the end of the Seventh Plan. The long-term scenario evolved by the Advisory Board on Energy in it's "Towards A perspective on energy Demand and Supply in India in 2004-05" (1985) indicates that by the year 2004-05, the demand for coal could be 450 to 540 million tonnes, non-coking coal constituting 380 to 472 million tonnes, most of this (216 to 302 mt) would be for power generation.

4.3 THERMAL POWER IN INDIA

In India the thermal power programme was launched in 1889 with the commissioning of 1 KW power station in Calcutta. Thermal power plants based on steam turbine technology were used for urban electrification in the earlier phase of power generation in India. This became the most important source of power supply and consequently industrial units set up private steam power plants in an attempt to produce enough power for their own consumption. Textiles industries combined this technology with production of process steam and heat and the result was the mushrooming of a number of such units all over the country, especially where hydro-electric plants could not be set up.


THERMAL POWER STATIONS
IN INDIA
Shrinagar
Amritsar
Shimla
Delhi
Jaipur
Lucknow
Patna
Shillong
Ahmadabad
Bhopal
Calcutta
Bombay
Bhuwaneshwar
Hyderabad
INDEX
THERMAL POWER STATIONS
Banqblore
Madras
Cochin
Trivandrum

Map. 4.1

When India became independent, the total thermal power generation capacity was nearly 756 MW which has escalated more than 50 times to 48,096 Mw in 1991-92. To enhance the electric supply in the country and to speed up power generation, the State Electricity Boards and the National Thermal Power Corporation (NTPC) were established under the States and Union Ministry of Energy respectively.

To satisfy the ever increasing demand for electricity the Indian thermal electricity industry has been installing bigger sets for the last forty years. During 1947-60 thermal sets between 50 to 60 MW were commissioned, during 1961-70 sets between 150 MW were commissioned, during 1971-80 sets between 100 to 210 MW and during 1981-88 sets between 210 MW to 500 MW were commissioned. The Government has been trying to develop advance technology to reduce the gestation period, production leakages, etc. To get the advangage of large scale economies, large capacity plants were developed.

The growth of total installed capacity over the years since independence has been significant with major break-through taking place in seventies and eighties, resulting in more than threefold increase in the installed capacity, between 1975-76 and 1991-92. A noteworthy feature of this growth pattern is the quadruple increase

4.4 GROWTH OF INSTALLED CAPACITY AND THERMAL POWER GENERATION

Growth of installed capacity and power generation of thermal plants and their share in over all capacity and power generation are given in table 4.3.

TABLE - 4.3

INSTALLED CAPACITY AND THERMAL POWER GENERATION

Year	Installed capacity (MW)	Share of thermal capacity to total generating Installed capacity (in %)	Generation (in MU)	Share of Thermal power generation in over all electricity power generation (in %)
1951	1,260	68.6	2,998	51.1
1956	1,825	63.2	5,367	55.5
1961-62	2,800	53.6	9,856	50.1
1966-67	5,335	52.8	19,642	54.0
1971-72	8,222	53.9	31,712	52.0
1976-77	11,804	54.9	50,245	56.8
1981-82	19,312	59.7	69,515	56.9
1986-87	31,740	64.4	28,851	68.6
1987-88	35,559	65.6	1,49,613	74.0
1988-89	39,677	67.2	1,57,711	71.2
1989-90	43,754	68.7	1,73,728	72.3
1990-91	45,768	69.3	1,86,452	72.3
1991-92	48,096	-	2,08,551	NA

Source: Central Electricity Authority, 1991-92.

in thermal capacity alone as compared to hydel and others. This has brought the thermal share to about 69 per cent in 1990-91 as compared to 54 per cent in 1976-77 as can be seen in table 4.3. The dependence on thermal generation has primarily been due to their low gestation period which by and large has helped in keeping pace with the rapid growth in the demand. For meeting the growing demand of power, the target addition of capacity in the Eigth Plan is about 42,000 MW, in which thermal will share about 32,000 MW. At the end of the Eigth Plan total installed thermal capacity would be around 71,000 MW.

The total power generation which was 2998 million units in 1951 increased to 1,73,728 million units in 1989, contributing around 72 per cent in overall electricity generation.

4.5 INCREASE IN GENERATING UNIT SIZE

At the time of independence the capacity addition was mostly in shape of installing 10 to 20 MW sets with a few exceptions of 50/60 MW sets. These were mostly imported sets. With the establishment of Bharat Heavy Electric Limited in 1962, the import of power equipment was discouraged. The initial manufacturing and commissioning of plants and equipments were in 30/60 MW range. It is argued that in a developing country like

CAPACITY-WISE THERMAL POWER UNITS IN INDIA

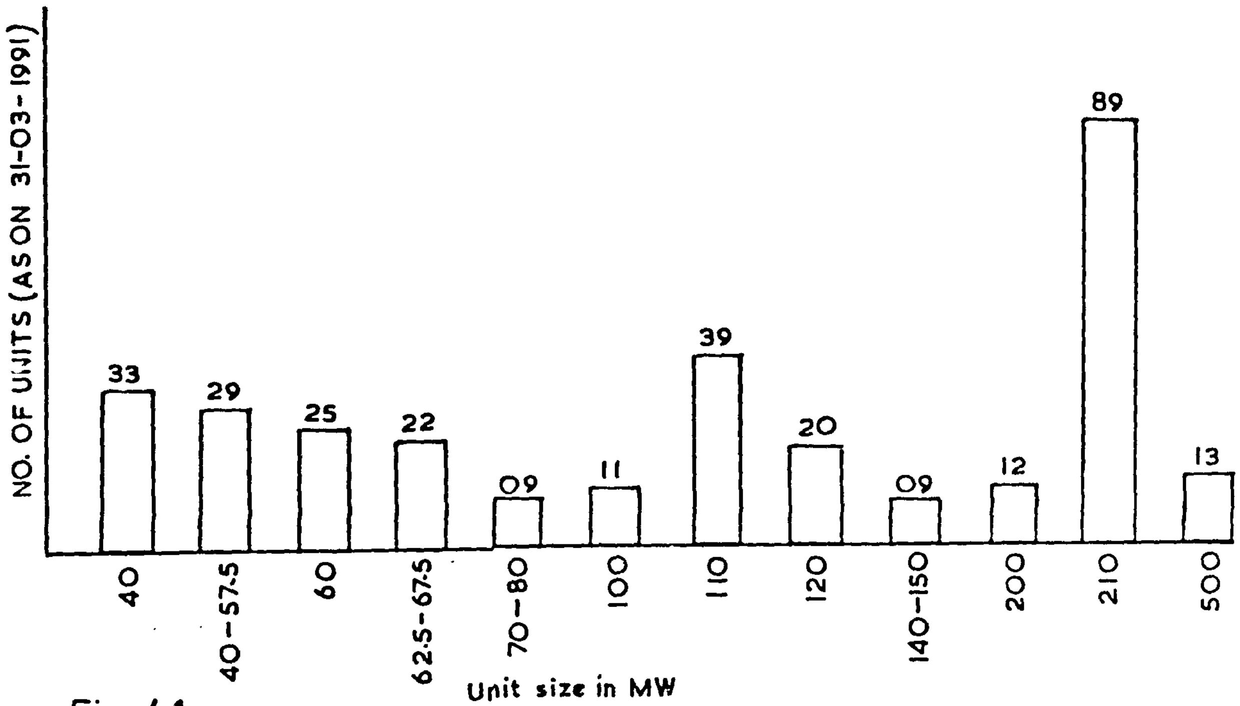


Fig. 4.1

India it is prudent to increase the size slowly to gain experience in manufacturing and operation of the larger units. (Guru, D.D., 1987).

Upto late sixties, the unit sizes adopted were less than 100 MW ranging from 7.5,15,30,50,67.5 etc. in the various thermal power stations depending upon the requirements of station capacity and other reasons, while in some stations a few units of 140/150 MW were also installed. The early seventies saw the beginning of units of 110/120 MW capacity. The introduction of 200/210 MW units in the late seventies and 500 MW in the eighties has resulted in a fast growth of thermal installed capacity. The table 4.4 depicts growth pattern in unit sizes since 1947.

TABLE - 4.4

GROWTH PATTERN IN UNIT SIZES

Year	Collaboration	Station first installed	Unit size (MW)
1947-50	-	-	10/15
1951-60	-	-	30/57.5
1961-76	-	-	60/100
Dec.'71	Soviet	Patratu	100
Dec.'77	LMW Soviet	Obra	200
March'83	Kwu Siemens	korba(NTPC)	210
Dec.'84	Kwu Siemens	Trombay	500

Source: Survey of Indian Industries, 1992.

The rapid growth of installed capacity made it imperative to adopt larger unit sizes to facilitate quicker capacity addition which provided added advantage of economy of scale and benefit of higher efficiency due to higher steam parameters. It is found that the larger sized thermal stations enjoy greater economy of savings in capital and fuel costs. "The principle of economy of scale as it applies to generator size also applies to the size of power plant. Because of the demand for more energy the size of generating units and power plants have been going up continuously. This results in economy in power generation. It has been estimated that doubling the number of generating units in a new plant brings 10-15 per cent savings; tripling upto 25 per cent savings" (chaman, K.).

The larger installed capacity that would have to be achieved by the Ninth Plan has made it necessary to explore the possibility of adopting still larger size to cope with higher installation rate required to meet growing power demands. For this purpose a sub group was constituted in 1989 to recommend the next higher size of thermal power plant.

The detailed study was carried out keeping in view the technical, economical and operational aspects particularly with reference to complexities of larger unit itself and of power system and grid stability, economy of scale, manufacturing capabilities and technological constraints.

Power system stability studies indicated that units upto 1000 MW could be incorporated in the large regional grids like Northern, Western and Southern. As regards the cost, a rough estimate indicates that the cost per MW of 660 Mw, 700 KW and 800 MW units (boiler and turbine package) reduces by 4.7 per cent, 5.9. per cent and 8.3 per cent respectively when compared with 500 MW cost. However, adoption of larger unit size would require that coal of consistent and better quality is supplied to such units. Water chemistry should be maintained meticulously and only trained operators should be put on these units.

4.6 PERFORMANCE OF THERMAL PLANTS IN INDIA

In view of the rapid increase in installation cost per KW and also the resource crunch, it is very essential to have the optimum utilization of the existing capacity more importantly in case of thermal plants which form bulk of our installed capacity. Thermal capacity at present constitutes over 68 per cent of the total installed capacity in the country and contributes more than 70

TABLE - 4.5

THERMAL POWER PLANT PERFORMANCE IN INDIA (in percentage)

Year	Plant load factor	Planned outages	Forced outages	Plant availability
1973-74	50.4	19.9	8.8	71.2
1976-77	53.3	9.8	13.2	77.0
1977-78	51.4	13.4	14.2	71.31
1978-79	48.3	14.3	14.7	69.11
1979-80	44.7	12.3	18.8	68.93
1980-81	44.6	13.31	20.27	66.42
1981-82	46.8	11.72	19.82	68.43
1982-83	49.4	12.52	20.93	NA
1983-84	47.9	11.52	24.07	NA
1984-85	50.1	NA	NA	NA
1985-86	52.4	NA	NA	NA
1986-87	53.2	NA	NA	NA
1987-88	56.5	NA	NA	NA
1988-89	55.5	NA	15.89	NA
1989-90	56.8	NA	15.83	NA
1990-91	53.8	NA	NA	NA

Source: Survey of Indian Industry, 1991.

per cent of total power generation. Plant load factor provides an indication of performance of thermal plants.

Table 4.5 shows that the plant load factor has been declining from 55.3 per cent in 1976-77 onwards till 1980-81. The all India average Plant load factor has remained virtually constant from 1979-80 to 1980-81. It improved since 1984-85 because a number of steps have been taken to achieve optimum utilizaion of the existing thermal capacity. With the implementation of Renovation and Modernisation schemes in various States Electricity Boards, to overhaul the old thermal power units, Plant load factor has registered an appreciable increase.

Table reveals that forced outages have increased from 8.8 per cent in 1973-74 to 24.07 per cent in 1983-84, planned outages were 11.25 per cent in 1983-84. Due to excessive outages full generating capacity has not been utilised in thermal plants which results in large scale power disruption. The above data also reveals that fored outages contribute heavily to the rather gloomy picture of availability of power from thermal stations. If their incidence could be reduced, the plant load factor could be raised resulting in higher generation without any addition to the installed capacity. It can also been found out that average plant load factor of the thermal plants can be improved by reducing the periods for planned shut-down of the unit for thorough maintenance work through proper organisation and coordination, also its partial and non-utilisation through construction of inter and intra-state grids of transmission lines for evacuation of the power and scientifically equitable distribution of the load on the power station. Careful attention to some of these aspects might enable the thermal units to operate under steady load conditions as 'base units' and thereby their overall performance could be further improved.

4.6.1 PLANT LOAD FACTOR OF DIFFERENT UNIT SIZES

The plant load factor has varried between different units. It has been observed in India that larger plants have a better plant load factor than the smaller ones. Table 4.6 shows that thermal sets of high capacity have higher plant load factor than the lower sized.

Table 4.6 indicates that 200/210 MW and 500 MW sets have achieved highest plant load factor much above the average plant load factor on all India basis.

So larger sets have substantial savings in capital and fuel costs as well as they contribute to increase in power generation too.

TABLE - 4.6

PLANT LOAD FACTOR ON DIFFERENT UNIT SIZES

Unit Size in (MW)	1989-90	1990-91
500	70.0	60.9
200/210	61.7	60.3
140/150	49.2	41.0
115/120	41.6	41.9
105/110	47.1	58.0
90/100	54.0	57.0
70-80	35.0	27.3
58-67.5	54.4	51.9
55-60	46.0	44.6
40-55	52.8	51.5
20-40	37.4	36.2
All India	56.5	53.8

Source: Report Central Electricity Authority (1990-91).

4.6.2 STATE-WISE PLANT LOAD FACTOR

The State-wise plant load factor of thermal plants from 1981-82 to 1987-88 is given in the table 4.7.

The plant load factor in Andhra Pradesh has continuously increased from 46.6 per cent in 1981-82 to 76.2 per cent in 1987-88 but it had declined after 1987-88. Table 4.7 depicts that in Punjab the plant load factor has increased tremendeously till 1987-88 in Tamil Nadu the plant load facator has improved and remained 60 per cent till 1991-92. The plant load factor has significantly decreased in Delhi Electricity Board from 67 per cent in 1986-87 to 44.7 per cent in 1988-89 but improved later on. The plant load factor had been very low in Uttar Pradesh State Electricity Board and remained below 40 per cent till 1985-86. It has increased immensely after 1988-89. The plant load factor is very low in the states of Haryana, West Bengal, Bihar, Orissa and Assam. During 1987-88 Andhra Pradesh, Rajasthan, Tamil Nadu, Gujarat, Punjab and Maharashtra achieved plant load factor higher than All India average of 54.4 per cent.

The plant load factor in many States continue to remain low and trail far behind the capacity. This low profile in generation and plant load factor is

TABLE - 4.7

PLANT LOAD FACTOR OF THERMAL POWER PLANTS BY STATES

Electricity Boards	1981 -82	1982 -83	1983 -84	1984 -85	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 92
Andhra Pradesh	46.6	51.1	54.6	54.4	64.8	69.7	76.2	69.6	65.3	58.3	61.7
Punjab	41.8	51.0	54.0	64.3	58.9	68.3	71.5	56.0	60.8	53.0	53.0
Rajasthan	-	-	72.3	57.2	57.6	54.8	71.5	52.6	57.7	42.8	65.7
Tamil Nadu	37.8	44.0	39.4	49.0	56.5	64.7	68.7	66.7	66.3	63.0	60.0
Karnataka		-	-	-	-	33.5	45.6	64.5	76.9	77.3	59.1
Gujrat	53.6	57.9	55.3	54.0	53.2	54.0	60.0	56.1	61.4	58.6	58.0
Maharashtra	49.4	50.2	51.0	46.6	54.8	50.7	57.0	53.4	62.0	57.4	59.4
Madhya Pradesh	49.4	58.5	53.1	51.7	53.3	53.8	53.3	50.1	57.8	57.4	60.8
Delhi	50.0	51.0	47.7	58.9	63.8	67.8	49.1	44.7	60.2	61.4	61.6
Uttar Pradesh	37.6	39.6	35.1	31.6	37.3	40.8	47.1	54.7	69.0	58.3	59.1
Haryana	37.3	32.2	31.1	34.7	32.8	33.8	40.6	41.2	44.1	34.6	45.8
West Bengal	37.6	38.5	35.9	36.5	42.2	41.8	38.6	36.7	42.7	43.8	46.2
Bihar	35.5	38.5	32.8	30.5	34.1	33.3	33.0	37.1	31.9	24.0	21.3
Orissa	35.9	35.2	33.3	32.2	31.7	31.7	32.5	30.9	35.6	34.0	30.0
Assam	34.8	36.9	34.2	29.6	27.5	18.5	31.0	27.6	27.8	27.7	24.6
J & K	09.1	01.0	01.5	-	-	-	-	-	-	-	-
Central Sector	-	-	54.8	55.4	61.9	64.9	63.3	62.6	62.2	58.1	64.7
All India	46.8	49.4	47.9	50.1	52.4	53.2	56.5	55.0	56.5	53.8	55.3

Source: current energy Scene in India, CMIE, 1989, 1993.

attributable to a number of techno-economic factors, prominent among them are low grade standard of coal which has high ash content and also including mixture of stones etc, non availability of spares in stock, inadequate maintenance, non availability of coal, Inadequate training of staff, defective supply of equipments, poor design and metallurgy of equipments.

4.6.3 PLANT LOAD FACTOR IN NTPC UNITS

The National thermal power corporation contributes approximately 18 per cent to total thermal power generation. The plant load factor in thermal units operating under NTPC has always been high than average national plant load factor as is evident from the table 4.8.

TABLE - 4.8

PLANT LOAD FACTOR - ALL INDIA AND NTPC BETWEEN 1982-83 TO 1990-91

Year	Plant load factor NTPC	Percentage All India
1982-83	63.6	48.6
1983-84	60.7	47.9
1984-85	58.1	50.1
1985-86	74.1	52.4
1986-87	79.6	53.2
1987-88	75.6	56.4
1988-89	68.4	55.0
1989-90	68.0	56.5
1990-91	60.9	53.8

Source: Annual Reports, National Thermal Power Corporation.

4.7 RENOVATION AND MODERNISATION OF THERMAL POWER PLANTS

The Government of India has initiated steps to improve plant load factor and for this prupose, a Centrally Sponsored renovation and modernisation programme has been implemented at 34 thermal stations comprising 162 units of different ratings, with a total capacity of 13,175 MW with a component of Rs. 500 crores. Under this programme, funds are advanced to the State Electricity Boards for renovation and modernisation of thermal power plants in the form of loans to be repaid in 15 annual instalments, with a moratorium of 5 years. During 1984-88 on amount of Rs. 243.91 crores was utilized under this programme.

As a result of the implementation of the entire renovation and modernisation programme, the plant load factor of the concerned power stations are expected to improve from an average of about 45 to 51 per cent.

4.8 PROBLEMS OF THERMAL POWER

Thermal power has a number of operational problems such as irregular supply of coal, substandard quality of coal, non-availability of spare parts, poor maintenance and inadequate operational techniques in thermal plants.

TABLE - 4.9

PLANT LOAD FACTOR: BEFORE AND AFTER RENOVATION IN UTTAR PRADESH

Station	Unit	Capacity (MW)	PLF before renovation average Fig.(%)	PLF after partial renovation April-Dec-1988
Obra	2	50.0	45.7	51.50
Obra	4	50.0	49.0	46.70
	5	50.0	43.8	56.70
	6	100.0	37.9	53.00
	8	100.00	43.2	45.60
	9	200	33.3	61.00
	10	200	31.4	56.40
	11	200	26.4	70.70
	12	200	40.2	75.50
	13	200	35.1	53.6
Panki	4	110	43.2	63.50
Harduaganj	5	60	40.9	52.00
	6	60	38.0	55.30
	7	110	37.4	46.80

Source: Department of Power, Report 1988-89, New Delhi, 1989.

4.8.1 SUPPLY AND QUALITY OF COAL

One of the problems of thermal power plants is the quality and supply of coal to them. There are 61 coal based thermal power plants in the country. Nearly 41.5 per cent of the total coal requirement in the country is for use in thermal power plants. All the power stations are linked for coal supplies from various coal sources according to the qualitative parameters fixed for them by technical experts. But some times low grade coal is supplied to them resulting in serious damages to the equipments.

The coal as available for thermal power plant are generally characterised by high ash and high moisture content. The low calorific value of coal supplied to power plants further harm the boilers. Many a time inferior or different grades of coal has been supplied to thermal power plants creating serious problems to boilers and other equipments which were basically designed to use different and superior grade of coal. Mnay plants have been designed to burn 5200 K. cal/kg and above with ash content 20-25 per cent but got coal as low as 3600 k. cal/kg. and 30-40 per cent ash content.

Table 4.10 shows deteriorating quality of coal to power plants.

TABLE - 4.10

QUALITY OF COAL SUPPLIED TO POWER PLANTS

Year	Average calorific(K cal/kg) value
1960-61	5,900
1965-66	5,200
1970-71	5,250
1973-74	5,000
1978-79	4,705
1979-80	4,585
1984-85	4,700
1985-86	4,650

Source: Department of power, 1986.

The low calorific value of the coal by itself may not be a cause of serious concern as it can be suitably taken care of while designing the boilers. Modern pulverised boilers are supposed to be more efficient in burning inferior coal and take comparatively les time for combustion. But the wide variation in ash content and moisture and extraneous materials in the coal supplied to power plant is rather difficult to manage.

In order to overcome the problem of poor coal quality, the process of coal benificiation at the coal mines is suggested. But the coal beneficiation process results in production of considerable amount of rejects which contains combustibles ranging from 1500-2000 K cal/kg. In order to have favourable economies of coal benificiation process, It is necessary to make use of such rejects. The present state of technology as available can burn such coal rejects. The fluidised bed boilers for coal benificiation can be located near the washeries. This however requires proper planning and proper policy framework.

The power sector constitutes the largest consumer of coal in India. The demand for coal in thermal power plants has been continuously increasing. It has increased from 41 million Tonnes during the First Five Year Plan to 247 million tonnes at the end of the Seventh Five Year Plan. But the supply of coal to thermal power plants has been falling short of demand. During the Seventh Plan as against a demand of 246 million tonnes, the supply was only 202 million tonnes, due to inadequate supply of coal, many plants, which are located at distant places from coal mines have to close down their operation.

The coal reserves are located far away from load centres. Transportation of bulk quantities of coal to the respective power stations cause a tremendous strain on Indian Railways which accounts for 90 per cent of the total coal dispatch. It also adversely affects the transportation of other essential commodities. The transport freight, sometimes, double the cost of coal itself and therefore, increases the cost of power supplied to the final consumers. Besides, due to many constraints like shortage of railway wagons, non availability of rail tracks etc, the Indian Railway is not able to transport the required amount of coal to the power stations in time.

The committee under the chairmanship of Mr. Mohd. Fazal (1987) which was set up by the Government to look into the problems of coal supplies to power houses made recommendation covering various aspects of coal supplies to power houses, such as linkages to be given to power houses from specific collieries, transportation of coal to power houses signing of agreement between coal India Ltd. and State Electricity Boards etc. Most of the recommendations of the committee have been accepted by the Government.

4.8.2 AVAILABILITY OF SPARE PARTS AND MAINTENANCE

The generation of electric power in thermal plants is also affected due to non-availability of spare parts and inadequate maintenance. Several thermal plants in the country experienced severe breakdowns of machines due to non-availability of spare parts in time. Unforced outages in the plants take place because most of the State Electricity Boards do not assess the need of spare parts at the time of installation of a plant.

Poor maintenance of plants is another cause of low capacity utilization in thermal plants. Schedule maintenance of thermal plants have been delayed to maintain the level of power supply, which results in forced outages in thermal plant and affect machinary adversely.

4.8.3 POOR OPERATION OF INDIGENOUSLY MANUFACTURED SETS

Another factor responsible for poor performance of thermal plants is the deficiencies in plants and machineries made indigenously by Bharat Heavy Electrical Limited. Problems in the sets made by BHEL take place due to inadequate control during manufacturing and commissioning of the project.

"It has been experienced that imported sets appear to have performed better than indigenous sets. In 1978-79 imported sets had a capacity utilization of 55 per cent against 44 per cent indigenous manufactured sets" (Business India, 1981).

The government had put a ban on the import of machineries after Bharat Heavy Electrical Limited started producing electric equipments and machinery inside India, but later on the Government had allowed import of certain machineries because indigenous production was not adequate to meet the growing demand of power in the country.

"Another area of concern is the long gestation period of indigenously produced sets. There is considerable time lag between ordering the power equipment and actual erection and commissioning (Guru, D.D., 1987).

4.8.4 OPERATION AND MAINTENANCE

Another problem of the thermal power stations is related with the operation and maintenance, which is not upto the mark due to poor technical knowledge of the personnel and lack of cooperation among the workers. The frequent incidence of outages is because of lack of involvement, indifferent attitudes of operating personnel apart from poor maintenance standards of working plants. The picture of frequent transfers of workers from one division to other divisions of power stations does not allow them to acquire efficiency in their jobs. All this leads to an adverse affect on the scientific operation and maintenance of power stations.

4.9 PROBLEM OF ENVIRONMENTAL POLLUTION

Thermal power plants create pollution due to high ash content coal available in India. Coal meant for the power houses has an ash content of between 15 to 55 per cent. After the combustion, the plant emits fly ash, soot, sulphur dioxides of nitrogen and coal dust. The wastes discharged include blowdown from boilers, furnace bottom ash and slag, water treatment ash etc. For example a 1000 MW thermal power station burning coal with 40 per cent ash content, will produce 35 million tonnes of ash during its operation life of 25 years. Besides, it will discharge 40 to 80 tonnes of sulphur dioxide a day. So for this, use of low sulphur coals, pre-combustion coal cleaning etc. may reduce air pollution. In order to remove particulars from the stock gases, machanicals like dust collectors, wet scrubbers are in use. The electrostatic precipitators have the advantage of high ash collection efficiency, low operating cost, low pressure drop, large gas flow handling etc. various measures have been taken up to minimise pollutant's impact on the ecology. New designs of coal burners and control of excess air have contributed signnifcantly to reduce the production of Nitrogen Oxides (No_x). Impact of SO_x emission is minimised by adopting very tall chimneys, viz 220 metres for 200/210 MW units and 275 metres for 500 MW units.

The environmental management of thermal power projects has recommended that plants should not be located within 25 Km of the cities, national parks historical monuments, etc. The National Thermal Power Corporation has started constructing high chimmnies to ensure protection from environmental pollution.

SUMMARY

From the above discussion it has been observed that thermal power energy is contributing the maximum share in total electricity generation in India. The growth of thermal installed capacity has increased rapidly compared to other sources of power generation, mainly due to their low gestation period. With the rapid increase in installed capacity, the size of thermal generating units have also become larger from 50 MW sets to 500 MW sets, due to high efficiency and advantage of economy of scale of larger units. The plant load factor, which provides an indication of performance of thermal plants, is a matter of great concern in Indian power sector. The plant load factor has been around 50 per cent during the last 20 years in India. Some times it is even less than 45 per cent. The performance of thermal power is not upto the mark due to inadequate supply of coal and substandard quality of coal being dispatched to thermal power stations. The availability of power is also low due to poor maintenance and operation techniques resulting in frequent breakdown of plants. Unavailability of spare parts also affect generation in thermal power plants. The next important source of power generation is nuclear power. The study of nuclear power has been taken up in the next chapter.

CHAPTER - V

NUCLEAR POWER IN INDIA

The nuclear power was primarily used for military purposes. Atomic bombing of Hiroshima and Nagasaki in 1945 was the first use of nuclear power for military purposes. The tragedy of 1945 is remembered with pain till these days. After this incident it was emphasised that atom should not be used for mass destruction but its use should be converted for peaceful purposes. This gave birth to the use of atom for power generation. In the early fifties of the twentieth century there was a talk of 'Atom for peace'. The United State of America's 'Atom for peace' proposal was devoted to the development of nuclear power technology in the successive years. The 'Atom for peace' programme had good impact on the development of nuclear energy for civilian use. From 1953 onwards international co-operation in civilian research of scientific character was freely expanded world wide. Although Atom for peace programme was launched in terms of broad coopration, political atmosphere of this period helped actually the competitive power reactor development programmes in the important industrialised countries like the United States, The United Kingdom, France and Canada.

The international competition was much more effective than co-operation in bringing about commercial nuclear power. Yet it took over a decade to achieve the development of an economical power reactor (Guru, D.D. 1987).

Nuclear energy became a definite source of power generation since 1950's when it was first utilized in the United States. It has gradually become an important source of generating electricity in addition to coal and hydro-sources.

In this chapter an attempt has been made to study the nuclear power development in India and its resources. Environmental impact of nuclear power generation has also been discussed.

5.1 EARLY PROGRAMME OF NUCLEAR POWER

From the very beginning the nuclear power programme has been controlled by the state in all the countries of the world. A lot of money is spent on nuclear research and development. Government agencies in all the countries have decided the amount of money being spent for nuclear power development. The aim of nuclear power development in the earlier years was mainly political. Nuclear power as a low cost of energy was not given any importance in the beginning. Because at that time enough oil was available at a low cost to produce electric power. But later on its economic significance as low cost of energy source was realised. The United States had taken a lead in making a reactor known as light water Reactor. Later on several other forms of reactors were made in the fission form of nuclear energy. The nuclear power generation of electricity became very popular gradually, because it was found to be economically cheap in relation to other fossil fuel resources. In the late sixties nuclear fuel became very important source of generating electricity in several countries of the world. Nuclear power became all the more important in the early seventies due to increase in oil prices.

5.2 PRODUCTION PROCESS

The production of nuclear energy takes place through fusion and fission technology. In the fusion technology, the release of energy is through the fusion of two elements, whereas in fission case, the release of energy is through the breaking of particular varieties of elements known as fuel.

Nuclear power production takes place when energy is released from an atomic nucleus like uranium undergoes fission or breaks into many parts and followed by the absorption of a neutron. Fission is processed in which neutron hits a heavy nucleus and is absorbed to form a compressed nucleus. The compound nucleus is unstable and may break into two or more smaller atomic nuclei with simultaneous emission of several neutrons. The neutrons may themselves be absorbed by other nuclei, and if enough of these uranium nuclei are there it is possible for the chain reaction tc develop. Chain reaction forms the basis of the operation of nuclear reactor. The total energy from nuclear fission of 1 tonne of Uranium is approximately as great as that of 2.5 million tonnes of coal. The intensity with which nuclear energy is released requires the use of sophisticated capital intensive equipment for its controlled conversion to heat and electric power.

5.3 RESOURCES REQUIRED FOR THE PRODUCTION OF NUCLEAR POWER

5.3.1 URANIUM

In 1789, M.H. Klaproth, a chemist discovered a new element in a sample of mineral pitch blende. This element was called uranium after the newly discovered plant Uranus. In 1939 otto Hahn and F. strassman discovered that the nucleus of the uranium atom can be used for nuclear power generation. If uranium atom undergoes fission into smaller parts forming the nuclei of other elements. Now though uranium is the main element needed for nuclear power plants, plutonium and thorium are also used for power generation. Uranium resources are mainly found in four countries of South Africa, Australia, Canada and Nigeria. The United States of America also produces significant amount of the product.

Uranium is made up of two isotopes, uranium 238 and Uranium 235. Of this, 99.3 per cent is accounted for by uranium 238 and 0.7 per cent by the Uranium 235. It is only uranium 235 which is easily fissionable and can be used for generating electric energy. Uranium 235 is one of the main elements used in nuclear power reactors.

The energy produced is in the form of heat and can be obtained from the reactors by a coolant. The zirconium is used for it by most of the power reactors. Coōlent is used because fission product which is highly radioactive and sometimes in gaseous form can not be transported as a fuel. This method helps to keep the fuel in a suitable material which is not a neutron absorber.

5.3.2 PLUTONIUM

Uranium 235 during fission is transformed into plutonium 239. Plutonium 239 can be used as a reactor fuel. One to three kgs of plutonium can be obtained from the fission generated by one tonne of uranium. The technology needed for this extraction is quite different from that used in uranium 235. To achieve large quantities of polutonium, the reactors need a moderator, heavy water. If this is not available then the only way out is through the use of light water, but here it becomes necessary to raise the fissile content of the uranium from 7.0 to 2.7 per cent. A fast breeder where plutonium is used enables a chain reaction to take place without the slowing down of neutrons. Here the neutrons escaping are usually fast but are captured in a fertile material placed around the reactors. This material is then converted into a fissile material and can be used to power other fast breeders. The excess generation of fuel can be built as third generation.

5.3.3. THORIUM

Thorium can be converted into fissile fuel material in a nuclear reactor for which energy can then be produced. It was discovered in 1829 by Berzillus. Thorium is more easily available than uranium. It comes from monozite, a sandy mineral found on the beaches or riverbeds. As it is insoluble in water, the deposits, are easily available. The isotopic content of thorium is unlike that of uranium. It can absorb a neutron and thus become a fissile material. Its energy value is much higher than uranium 235 (Hans, A.1980).

5.4 GLOBAL SCENARIO OF NUCLEAR POWER

At present, over 417 nuclear reactors with a total installed power generation capacity of nearly 2,97,000 MW are in operation in twentysix countries and generate more than 16 per cent of the world's electricity. U.S.A. accounts for the largest single programme with 106 reactors and about 93,000 MW of installed capacity. France has an installed nuclear power generation capacity of over 49,000 MW which accounts for some 70 per cent of its total electricity generation. In Asian region, Japan has a nuclear power generation capacity of about 27,000 MW, South Korea has 5,400 MW and Taiwan 4900 MW, erstwhile Soviet Union had a nuclear power generation capacity of over 33,000 MW with 55 operating reactors. Inspite of being endowed with large reserves of coal oil and gas, economic considerations had governed the erstwhile Soviet Union's plans for substantial increase in nuclear power generation capacity.

Table 5.1 shows the share of Nuclear power in different countries. The table indicates that the share of nuclear electricity is quite sizeable. France and Belgium are generating maximum electricity through nuclear sources.

TABLE - 5.1

SHARE OF NUCLEAR ELECTRIC POWER IN DIFFERENT COUNTRIES

Countries	Percentage share of Nuclear power
France	70
Belgium	60
Republic of Korea	50
Hungary	49
Sweden	45
Taiwan	44
Switzerland	41
Spain	38
Finland	35
Germany	34
Japan	27
U.K.	21
U.S.A.	19
Canada	15
Soviet Russia	12
Argentina	11
India	02

Source: Annual Review, Power - 1989-90, Indian Journal and River Valley Development.

COUNTRIES WITH NUCLEAR SHARE IN TOTAL ELECTRICTY PRODUCTION

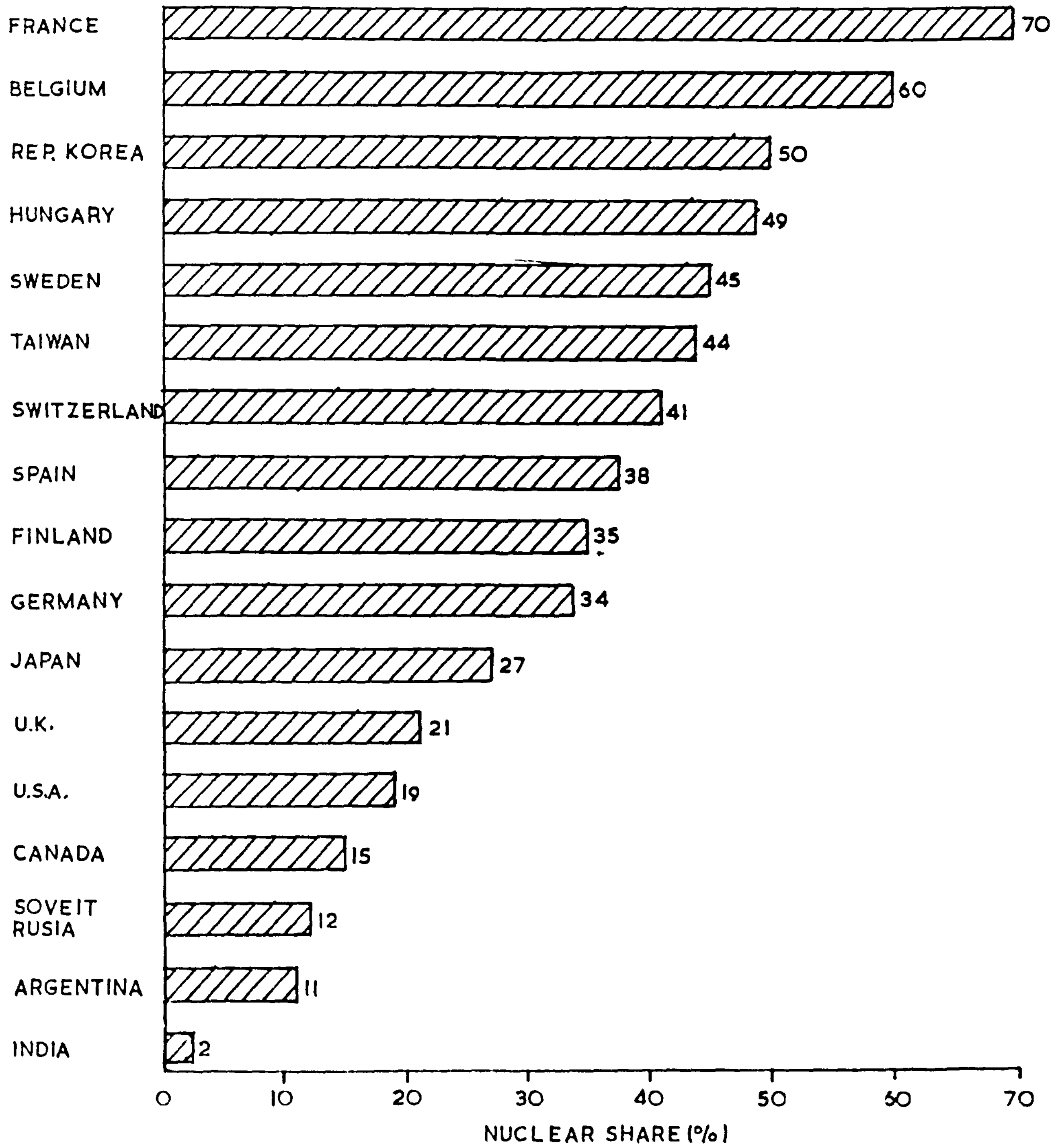


Fig.5.1

Nuclear power has become a well established energy source of electricity in most of the industrialized and in several developing countries.

"The estimates made for development of nuclear power for 2000 A.D. is around 2400 GW(e). But as it is time consuming process the capacity was expected only 450 GW(e) during 1990. The break up of the estimates for nuclear generating capacity shows that North America would have 200-300 GW(e), Western Europe 210-300 GW(e), Japan 80-90 GW(e) by the end of 2000 A.D. Because of such proposal to increase the nuclear power capcity the demand for uranium is going to increase considerably during these years because contributions from breeder reactors is going to be negligible upto the end of 2000 A.D. The world reserves of Uranium has been estimated by international Atomic energy Agency (IAEA) at 1.81 million tonnes. This figure is divided among twenty six countries excluding the Soviet Russia, approximately 28 per cent in the U.S.A., 19 per cent in south Africa, 20 per cent in Canada, 14 per cent in Australia and remaining 19 per cent scattered among other twenty nations (Boyd, J. 1978).

Nuclear power achieved a rapid growth after the oil price shocks of the 1970's and it provided the necessary energy alternative and energy independence for those countries which lack indigenous energy resources. The economic benefit of nuclear power has also been well established in many countries. A study published in 1986 by the OECD Nuclear Energy Agency Shows that, in most countries, electricity generation with nuclear power plant is cheaper thant with coal fired plants. Several other studies on the economics of electricity production from coal and nuclear sources have shown that excepting for those regions where coal is readily available, nuclear power is substantially cheaper than coal based power. It also becomes clear from the fact that France and Belgium which generate a large percentage of their electricity from nuclear energy also have the lowest cost electricity in Western Europe.

5.5 ECONOMICS OF NUCLEAR POWER

Nuclear power is considered better source of energy over other forms of generating electricity because of its economy in fuel consumption. "The masses of different fuel required to produce 1 MW a day in case of nuclear energy is much lower as compared to others. Thus the annual fuel for 1 GW (1000 MW (1) 330 MW thermal power station at 30 per cent efficiency and 70 per cent load factor, the annual fuel required for oil is 1.5 million tonnes and in case of coal is 2.3 million tonnes but in case of enriched uranium is LWR in only 26 tonnes and in terms of natural uranium it is 150 tonnes (Guru, D.D. 1987).

As compared to coal based power plants nuclear power plant requires low level of inventory which is to be maintained for efficient and continuous operation of the power plants.

"The inventory level in case of nuclear energy source of generating electricity depends on two conditions. Firstly it must be sufficient for maintaining the chain reaction. Secondly the inventory should be such that the rate of heat production per unit mass of fuel is low enough for the circulating coolant to remove the heat sufficiently quickly so that the fuel and its container remain at reliable operating temperature. For these consideration the inventory requirement is of much lower dimension than those of other forms of power generation. Hence the advantage in inventory cost in case of nuclear energy would be considerably"(Guru, D.D. 1987).

5.6 NUCLEAR POWER IN INDIA

The relevance of nuclear power as an important supplementary source to coal and hydro power in India, was realised nearly four decades ago when the objectives of atomic energy programme was defined as the generation of electricity for industry, medicine, agriculture and for research.

"The basic philosophy behind India's nuclear power programme is to make use of the existing limited quantity of natural uranium to install thermal rectors of the heavy water type during the first stage. The plutonium produced in these heavy water reactors will then be used to feed fast breeder reactors which will in turn convert the depleted uranium recovered from the spent fuel discharged from the heavy water reactors or thorium from our vast resources"(Ramanna, R. 1980).

The coal resources in India is unevenly distributed with most of it deposits found in the eastern and central parts of the country far away from many of the major coal centres. Environmental impact of burning coal from power generation is a matter of great concern. The carbondioxide released by the thermal stations may eventually lead to a greenhouse effect that could limit burning of coal in future for power generation. Taking up new hydel power schemes is getting difficult due to concerns of submerging valuable forest areas and problems posed by rehabilitation of relatively large population. Within the prevailing constraints, hydel and coal will continue to play an important role in the energy scene of India. However, in addition to exploiting all available hydel and coal resources in the country, nuclear power to complement other sources for balanced power development is becoming very important.

5.7 URANIUM RESERVES IN INDIA

India's total uranium reserves are estimated to be around 52,000 tonnes of uranium and about 320,000 tonnes of thorium (Ramanna, R. 1980). Initially most of the exploration work of the Atomic Minerals Division was confined to the singhbhum district of Bihar, but has now spread all over the country.

Of the various ore reserves, about 49,000 tonnes of $U_3\ O_3$ are considered commercially exploitable and are located mostly in Singhbhum district and in Madhya Pradesh Meghalaya and Karnataka.

The first mine and mill was set up at Jaduguda in Bihar in 1967 by the Uranium Corporation of India Ltd. Since then, significant finds in Himachal Pradesh, Karnataka, Madhya Pradesh and uttar Pradesh have added to nuclear capacity.

5.8 NUCLEAR POWER DEVELOPMENT IN INDIA

Among the developing countries in the world, India is in unique position of having achieved significant progress in peaceful utilization of nuclear energy for electric power generation. It is almost forty years ago that the foundation for this development was laid by the great visionary, DR Hami. J. Bhabha, the founding father of India's nuclear energy programme. With the help of Tata Institute of Fundamental Research, he provided the nucleus around which the nuclear power programme grew.

Organised research in nuclear science began in 1945, with the establishment of the Tata Institute of Fundamental Research in Bombay. The Atomic Energy Act was passed in Parliament soon after the country gained Independence in 1947, and set forth India's objective for the development and utilization of atomic energy solely for peaceful purposes. It was however, only in 1954 that the Government established a Department of Atomic Energy charged with the sole responsibility for all nuclear activities in the country. Until that time the work of the Atomic Energy Commission had been restricted to the survey of radioactive minerals setting up plants for processing monazite and limited research activity in the area of electronics, methods of chemical analysis of minerals and the recovery of valuable elements from available minerals. In 1954, a multi-disciplinary centre for research and development was set up in Trombay, near Bombay, which is known as the Bhabha Atomic Research Centre (BARC). The fundamental criterion in setting up of this national centre was that the institution should grow as various groups developed indigenous know how and became able to expand in a useful and co-ordinated manner. The Bhabha Atomic Research Centre has grown over the years to become the foremost institution of science and technology in the country.

Today India is among the eight countries in the world, and the only developing country, to have the complete fuel cycle, right from uranium exploration, mining fuel fabrication, heay-water production and reactors, to reprocessing and Waste management (Setha, N.H. 1980).

India has also reached a stage where its indegenously developed know - how can support all the required activities encompassing feasibility Studies, site selection, detailed project design, construction, commissioning and operation of any nuclear plant in the entire fuel cycle chain.

5.9 STRATEGY ON NUCLEAR POWER DEVELOPMENT

The basic policy governing the development of nuclear power generation in India has been based on Safety and Self-Reliance.

To achieve these objectives a strong Research and Development base was created within the Department with the following objectives -

(i) To build a cadre of scientific and technology manpower to meet the needs of the programme,

(ii) To build and operate research reactors and Later embark on nuclear power reactor programme,

(iii) To develop capability for design and safety review of nuclear power plants, and

(iv) To develop industries for special material like nuclear fuel and heavy water.

The first decade and half, therefore, saw the setting up of an experimental reactor and the nucleus of a multi-disciplinary Research and Development establishment at Bombay. It is this foundation that forms the backbone of India's nuclear energy programme today.

The strategy adopted for exploiting nuclear energy comprised of three stages wherein different categories of reactors would become operational are as follows.

Stage I: Pressurised heavy water reactors (PHWRs). Using natural uranium as fuel to generate power and plutonium.

Stage II: Fast breeder reactors (FBRs) using as fuel the plutonium extracted by reprocessing the spent fuel of pressureised heavy water reactors. Simultaneously these reactors would also yield additional fuel using thorium as a breeding material.

Stage III: Thorium based reactors which would be fuelled by uranium - 233 obtained from the reprocessing of irradiated thorium from the fast breeder reactors. These reactors would also irradiate more thorium to breed nuclear fuel for subsequent nuclear power units.

Given the country's resources of natural Uranium and thorium, the three-stage nuclear power reactor programme envisages building a series of natural uranium, heavy water moderated and cooled reactors which, apart from generating power, would also produce plutonium. The plutonium produced in the first generation reactors would be used as fuel in the fast reactors which in turn will breed either more plutonium or uranium-233 with thorium used as blanket material. The third stage reactors are expected to use uranium-233 along with thorium in a breeding mode for utilising the large reserves of thorium for generating electricity. Pressurise heavy water reactors forming the main line indigenous programme

TABLE - 5.2

NUCLEAR POWER INSTALLED CAPACITY AND GENERATION

Year	Installed Capacity (MW)	% of total installed capacity	Generation (MU)	% of total power generation
1969-70	420	2	1339	2
1974-75	640	3	2206	3
1979-80	640	2	2876	2
1984-85	1095	2	4078	2
1985-86	1330	2	4985	2
1986-87	1330	2	5023	2
1987-88	1330	2	5034	2
1988-89	1565	2	5817	2
1989-90	1565	2	4624	1
1990-91	1565	2	6244	2

Source: All India Statistics, Central Electricity Authority, 1990-91.

utilise the available indigenous natural uranium reserves in an efficient manner.

5.10 INSTALLED CAPACITY AND POWER GENERATION

Table 5.2 shows the installed capacity and generation of nuclear power.

It is clear from table 5.2 that installed capacity of nuclear power has increased from 420 MW in 1969-70 to 1565 MW in 1990-91. But its percentage share remained constant at 2 per cent to total capacity. Total installed capacity has raised to 1330 MW at the end of the Sixth Plan with extension of neuclear power plants in southern region with the capacity of 420 MW. During the Seventh Five Year Plan three more 235 MW pressurised heavy water reactors were commissioned.

The Department of Atomic Energy of the Union Government has drawn up a programme for implementation during 1985-2000 A.D. including opening of new uranium mines and augmentation of fuel fabrication facilities to meet the basic input for nuclear power generation. A proposed 500 MW prototype fast breeder reactor is expected to commence operation by mid-ninties. Other programmes included setting up 12 reactor of 235 MW capacity, 10 to 12 reactors of 500 MW capacity.

With currently known reserves an ultimate capacity of 350,000 MW could be attained by the second half of the 21st century using heavy water reacators followed by fast breeders. At present only a small per centage of India's electric power is generated from nuclear sources. This percentage would increase in the years to come in view of the programme of development of nuclear energy.

5.11 INDIGENISATION OF NUCLEAR PLANTS

The indigenisation of nuclear plant has been possible of vast number of scientist and engineers trained in nuclear technology. The experience with regard to design in the case of the first nuclear power plant at Tarapur was limited to design review as this plant was built on turn-key basis. Nuclear designs for the second nuclear power plant at Rajasthan were from atomic Energy Canada limited (AECL), Canada. This unit was built on Indo-Canadian collaboration. When the units at Rajasthan were built, a team of Indian designers worked along with their Canadian counterparts in adapting the designs to Indian conditions. This provided valuable experience. Since there existed experience in construction of research reactors, which combined with the experience in the first two nuclear power plants gave enough confidence to take up the design of the third atomic power station at Madras as a totally indigenous effort. The fourth nuclear power station at Narora was also manufactured indigenously. A number of design improvement nuclear systems have been incorporated to suit the scismic conditions of the site and updating the technology in line with the international pracatices.

Early association in construction of research reactors and power reactors and trained manpower has made indigenisation possible. Research and Development work at the Bhabha Atomic Research Centre has mainly supported the indigenous design of the nuclear power plants.

5.12 SAFETY AND ENVIRONMENTAL IMPACT

Nuclear power development has recieved maximum attention from the point of view of safety. Beginning from the mining of uranium to the management of radioactive effluent, safety has been the main concern in the development of nuclear power. Until the accident at Chernobyl Power Station in the erstwhile USSR in April 1986, there had been no fatalities attributable to a civilian nuclear power reactor anywhere in the world. In the case of Chernobyl accident, fatalities were confined to those who were either plant operators or those deployed to fight the fire and contain the accident. As a result of the initiatives taken by the

International Atomic Energy Agency (IAEA), the causes of the accident have been studied in great depth by the internaional nuclear community. The report of IAEA indentifies that the accident was caused by a remarkable range of human errors and violations of features which compounded and amplified the effects of the errors and led to the reactivity excursion. The accident was due to an extraordinary combination of an unusual set of circumstances. Arising from indepth reviews of this accident much importance is being placed on the man-machine interface. Augmentation of the automated systems that ensure reactor safety even under highly improbable abnormal conditions has been taken up in nuclear installations. Greater reliance is also being placed on operator training, qualification and requalification through use of simulators, and review of operating procedures by independent experts. More recently, system for global exchange of operating information and experience between operating nuclear reactors has been taken up, so that operating personnel at nuclear power stations can get full benefit from experience elsewhere in the world to deal with off design conditions or other abnormal situations at their installations.

In this context it is to be noted that the accident of the type occured at Chernobyl cannot be extrapolated to Indian pressurised heavy water reactors (PHWRs) due to inherent features of these systems using natural uranium as fuel and heavy water as moderator. The double containment principle adopted in the present generation of PHWRs ensures multiple barriers for containing radiation that may emanate from the reactors under adverse conditions.

In India, the safety aspects of the nuclear power plants are carried out during all the stages commencing from site selection to commissioning and also right through the operational life time of the plant. Atomic Energy Regulatory Board reviews the various safety aspects before a station is licensed. During the operational stage of the station, a technical specification for each station specifies the operational and safety limits to be adhered to. Unusual occurrences are to be reported and after analysis remedial action is taken promptly. Surveillance relating to health physics aspects including releases during operation are carried out by Health Physics Division, BARC, duly reviewed by Safety. Review committee of AERB. The experience relating to radioactive releases to the environment in the operating stations indicates that releases are only a fraction of the authorised limits and radiation dose due to these amounting to less than 2 per cent of the natural background radiation. Moreover, safety is built into the design by appropriate engineered safety features evolved over a period of time with long operating experience of the stations in the world over. The probability of any uncontrolled release of radioactivity from the nuclear power plants due to an accident is negligibly small and adequate engineered safety features are provided to mitigate the consequences even in the unlikely event of such an accident. As a matter of abundant caution, off-site emergency plants are available to deal with such situations. For any uncontrolled escape of radioactivity from the fuel (which is the primary source of radioactivity), five barriers i.e. fuel itself, cladding of the fuel, primary pressure boundary and two containments are to be crossed. As a defence in depth concept, an exclusion zone of 1.6 km around the reactors is also eastablished where public habitation is not allowed. This area is acquired and is under the control of the operating station.

There are no chemical pollutants of significance such as Co_2 from nuclear power plant unlike from a coal fired power generation.

"It is generally not known that the coal that is used in a coal-fired power station and the residual fly ash that is left in the open are both radioactive. Both contain radium 226 which is an emitter of beta rays. Each 500 MW coal fired plant produces about 18,000 trucks loads of ash, whereas the total amount of fuel discharged from a nuclear power station of similar size would be about 30 trucks loads including the shipping casks, or half a truck load without a casks. More than 95 per cent of the material in the fuel discharged from the nuclear plant will be recovered for successive use as nuclear fuel and the amount of radioactive waste that has to be managed on a long-term basis is small. The concentrated and solidified nuclear wastes are fixed in a special type of glass and stored in underground depositories" (Ramanna, R. 1980).

Since there are no chemical pollutants such as Co_2, as a result environmental impact relates to release of low level radioactivity to the environment during normal operation. The policy relating to treatment and management of radioactive wastes from the plant is essentially segregation at source, treatment, concentration and containment of most of them and surveillance. Therefore, the releases of radioactivity to the environment are only a small fraction of that generated in the plant. These releases are well within permissible limits and are in line with the requirements stipulated by Atomic Energy Regulatory Board (AERB).

An Environmental survey and Micro Meteorological laboratory (ESML) is set up at each site. The objective of ESML is to conduct pre-operational survey and also carry out surveillance during operation of the nuclear power plant. The pre-operational survey is aimed at determining natural background radiation, radioactivity levels at site, obtaining data on the demographic pattern and living habits of the population around, evaluating recipient capacity of the local environment, the eco-system and its characteristics and developing models for predicting radiation doses from expected releases. The operational monitoring programme continues throughout the lifetime of the plant. An area of about 30 Km radius around the plant is normally covered in this programme. In respect of environmental impact due to land acquisition, the requirement of land for nuclear power plants is much smaller compared to hydel projects and comparable to thermal power plants.

With the number of nuclear power reactors operating in 26 countries the technology in waste management and decommissioning processes are developing continuously. India is not lagging behind the industrialised countries in these areas due to an early impetus given to research and development programmes in the Department of Atomic Energy.

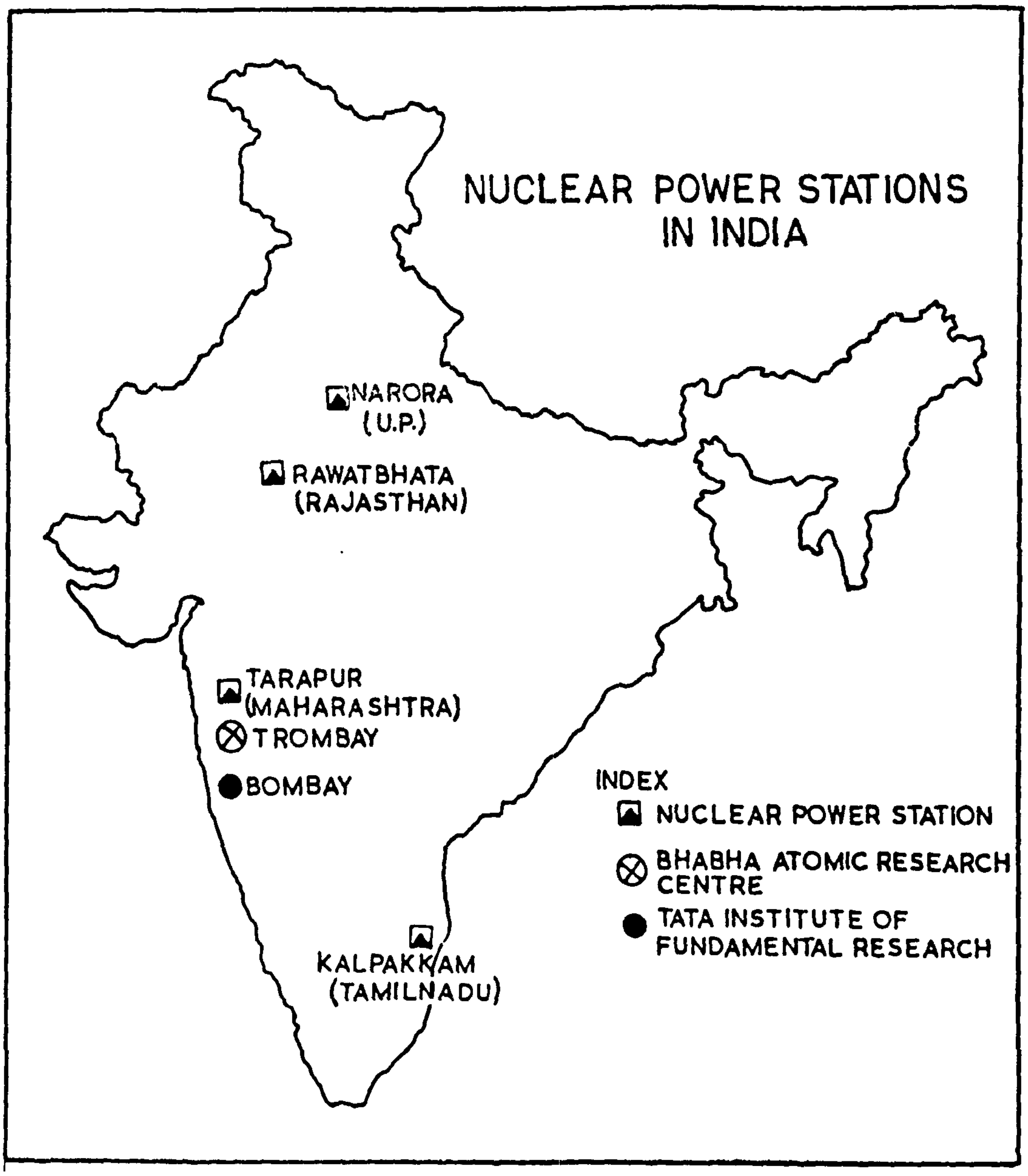
Radioactive wastes from nuclear power plants are mostly of flow and intermediate levels. Treatment and safe disposal of these wastes have already been demonstrated and facilities for this purpose are in operation at different nuclear installations in the country.

5.13 NUCLEAR POWER STATIONS IN INDIA

At present there are four nuclear power stations in India namely Tarapur Atomic Power Station, Rajasthan Atomic Power Station, Madras Atomic Power Station and Narora Atomic Power Station.

5.13.1 TARAPUR ATOMIC POWER STATION

India's first nuclear power station at Tarapur, near Bombay, comprises of two enriched Uranium fuelled boiling water reactors (BWRS), each of about 200 MW capacity was commissioned in 1969. It was built by United States firm on a turn-key basis. The decision to go in for a boiling water system (BWRs) for the first nuclear power plant was prompted by the desire to demonstrate the


NUCLEAR POWER STATIONS
IN INDIA
NARORA
(U.P.)
RAWATBHATA
(RAJASTHAN)
TARAPUR
(MAHARASHTRA)
TROMBAY
BOMBAY
KALPAKKAM
(TAMILNADU)
INDEX
NUCLEAR POWER STATION
BHABHA ATOMIC RESEARCH
CENTRE
TATA INSTITUTE OF
FUNDAMENTAL RESEARCH

Map. 5.1

economic viability of nuclear power in the country without delay by using a proven system. This station was a turnkey project awardd to General Electric of the USA on the basis of a global tender. The involvement of Indian personnel was, however, substantially more than the usual turn-key project. Indian scientists and engineers were responsible for all the preliminary work such as site selection, tender preparation and evaluation and also participated, to the extent possible, in the review of detailed designs construction, inspection and testing of equipments and commissioning activities.

Since commissioning in 1969, these reactors have operated at an average capacity of over 50 per cent and have been supplying the cheapest non-hydel electric power in the country. Tarapur's performance has been wholly satisfactory and comparable with other stations of similar vintage elsewhere in the world. The operation of the station during the past 20 years has proved the economic vaibility of nuclear power in this country.

5.13.2 RAJASTHAN ATOMIC POWER STATION

During the sixties a collaborative venture with canada was also taken up for setting up two pressurised heavy water reactors based nuclear power programme, this had the objective of achieving self-reliance in PHWR technologh as early as possible. Considerable efforts were also devoted to creating capabilities within the country for production of heavy water, nuclear fuel and ziracaloy components required for critical reactor internals. This venture resulted in the setting up of two 220 MW reactors at Rajasthan Atomic Power Station, Kota. In this project, India retained the responsibility for construction and installation activities while Canada undertook to supply the design and major equipment. India took the risks involved not only on the prices and schedule that such a procedure entailed but also in the capital investment in a system which was in its initial Stages of development. While major enquipment for the first unit of this station was imported, part manufacture of some of the major components was undertaken in India. It also fabricated many items of auxiliary equipment and half the initial fuel charge for the first unit. The efforts to rely on indigenous resources were intensified for the second unit of this station and major components such as the calandria - end -shields, steam generators and fuelling machines were manufactured in the country. These two units became operational during 1973-74 and 1980-81 respectively. The first unit had to undergo extensive repairs of a very complex nature to plug the leak of light water from one of its endshields. On the other hand, the second unit at Rajasthan has been performing very well.

5.13.3 MADRAS ATOMIC POWER STATION

The third atomic power station, consisting of two heavy - water reactor units of 235 MW each is built near Madras in Southern India. The completion of the first unit of the Madras Atomic power station at Kalpakkam in July 1983 was an important landmark in the country's nuclear power programme. This was undertaken as national venture with full responsibility for design, manufacture, construction and commissioning resting with Indian engineers and technologists. Several design modifications and improvements have been introduced at this plant for reasons of economy and to take into account local conidtions. The second unit went into service towards the end of 1985. Both these units performed very well during the earlier months of the year 1987-88. Subsequently, the first unit had an extended outage upto Feb. 1988 following the detection of cracks in HP turbine blades. Broken blades in the turbine and cracks in turbine blades of second unit of Madras Atomic Power Station also resulted in an outage of this unit from Dec. 1987. Despite these problems, the Madras Atomic Power Station generated nearly 1900 million units of power during 1987-88.

5.13.4 NARORA ATOMIC POWER STATION

The fourth power station at Narora in the state of Uttar Pradesh in Northern India counsists of two 235 MW heavy--water reactors. These reactors have several new design features and concepts, including earthquake resistant design of the buildings and reactor components. Among the new features of the Narora reactors are an integral calandria-end-shield assembly, two independent fast acting shut down systems for safety and reliability and a simplified water-filled calandria vault.

First unit of Narora Atomic Power Station was commissioned in 1989. Another unit was commissioned in 1991. Both the units are generating electricity.

5.14 ELECTRICITY GENERATION BY NUCLEAR POWER STATIONS

Electricity generated by atomic power stations during the Seventh Five Year Plan is given in table 5.3.

TABLE - 5.3

NUCLEAR POWER GENERATION

Unit	Gross generation in million Kwh	Availability factor (%)	Capacity factor(%)
TAPS-I	4519	70	64
TAPS-II	4491	71	64
RAPS-I	1428	35	15
RAPS-II	6680	78	69
MAPS-I	5027	62	49
MAPS-II	3438	57	41

TAPS - Tarapur Atomic Power Station

RAPS - Rajasthan Atomic Power Station

MAPS - Madras Atomic Power Station

Source: All India Statistics, Central Electricity Authority 1987-88.

The Tarapur Atomic Power Station and Rajasthan Atomic Power Station-II have performed well during the Seventh Five Year Plan. The lower capacity factor Madras Atomic Power Station and Rajasthan Atomic Power Station-I were mainly due to unforseen problems during 1988-89.

Nuclear Power will play an important role in electric power generation in the years to come. To a country like India that has the constraints of limited fossil resources and a large population, such a power can definitely yield significant benefits during the coming decades.

SUMMARY

The relevance of nuclear power as an important supplementary source to coal and hydro power in India, was realised nearly four decades ago when the objectives of Atomic energy programme was defined as the generation of electricity.

The coal resources in India is unevenlly distributed with most of deposits found in the eastern and central parts of the country far away from many of the major load centres. Environmental impact of burning coal for power generation is a matter of great concern. Taking up new hydel power schemes are getting difficult due to concerns of submerging valuable forest areas and problems posed by rehabilitation of relatively large population. Within the prevailing constraints, hydel and coal will continue to play an important role in the energy scene of India. However, in addition to exploiting all available hydel and coal resources in the country, nuclear power to complement other sources for balanced power development is becoming very important.

Among the developing countries in the world, India is in a unique position of having achieved significant progress in peaceful utilization of nuclear energy for electric power generation. The Atomic Energy Act was passed in Parliament soon after the country gained

Independence in 1947. In 1954 the Government established a Department of Atomic Energy charged with the sole responsibility for all nuclear activities in the country.

The installed capacity of Nuclear Power has increased from 420 MW in 1969-70 to 1965 MW in 1990-91. With currently known reserves an ultimate capacity of 350,000 MW could be attained by the second half of the 21st century. At present only a small percentage of India's electric power is generated from nuclear sources There are four nuclear power stations in India, producing electricity.

The Department of Atomic Energy of the Union Government has drawn up an ambitious programme for implementation during 1985-2000 A.D. including opening of new uranium mines and augmentation of fuel fabrication facilities to meet the basic input for nuclear power generation.

In India, the safety aspects of the nuclear power plants are carried out during all the stages commencing from site selection to commissioning and also right through the operational life time of the nuclear power plant.

CHAPTER - VI

STRUCTURE OF POWER SECTOR IN INDIA

By structure of power sector, we actually mean its organisation, i.e. how the power sector is being looked after by the different bodies in generation and distribution of power.

The structure of power industry as we see it today in India has emerged over a period of nearly hundred years. At the beginning of the twentieth century a few private companies were operating small power stations mainly catering to urban loads. Subsequently some municipalities and state Governments entered the field of power generation, again to meet the urban loads and small motive power requirements. Electric power was made available to the public in the beginning of twentieth century though its generation was minimal. During 1930's few state (provincial) Governments and princely states expanded their activities not only to meet the urban loads but also to provide the inputs for industry and agriculture. Prominent among them was the former state of Mysore, which built a hydro power station that ushered in an era of industrialisation in the State.

In this chapter an attempt has been made to throw light on the structure of power sector and its institutional framework.

6.1 THE INSTITUTIONAL FRAMEWORK

In 1910 the Indian Electricity Act was passed to govern the grant of licences for electricity generation and distribution. The main aim of this Act was the issue of licences by the State Governments to the suppliers of electric power. The licensees were then expected to conform to certain basic operational procedures and provisions to ensure security of those persons working on electrical equipments and appliances etc. besides, they were also required to submit the accounts to the respective State Governments. State Advisory Boards were also established to help the State Governments in policy planning regarding the power sector. A Central Electricity Board was also set up whose responsibility was to promulgate, in the public interest, rules specifying service and safety conditions, as well as the manner in which licensees must make annual report. This Act of 1910 was more concerned with the regulatory and safety aspects of electricity than with the organisational structure of the industry itself. The organisational structure of power industry has emerged only after the Electricity (Supply) Act, 1948 was passed.

Though governmental control on power sector started in 1940's when some Municipalities and Provisions Governments began dealing with this sector, but supply of power was not balanced throughout India. Hydro electric plants and associated grid systems were established to transmit power over long distances but these power plants, established near load centres were actually supplying power to urban areas. Therefore, before independence the supply of power was marked by unbalanced development. As there was no rigid legislation, uniformity in development and supply of power did not exist.

After Independence the Constitution of India put electricity in the concurrent list and it became possible for both the Union Government and State Governments to legislate on the subject. It therefore, came to fall under the control of both the Central and State Governments. In 1948, a new break-through came with the Electricity Supply Act, which enabled proper control of power. The Act provided the establishment of new statutory organisation, the Central Electricity Authority (CEA) and the State Electricity Boards (SEBs), which became the main supplying agencies, for power throughout the country. The Act was drafted with the assistance of experts from the United Kingdom and was drawn mainly from

British experience and British Act of 1926. The Electricity (supply) Act 1948 was passed on 10th sept. 1948. The objective of the Act was to provide for the rationalisation of the production and supply of electricity, for taking measures conducive to power development.

The 1948 Act, together with the Industrial Policy Resolution of 1956, directed the development of power in independent India. Industrial policy of 1956 includes the generation and supply of electricity as an industry which would be an exclusive responsibility of the State. After independence development and promotion of power came in the hands of the Government of India and private companies expecpt Tata Electric Company, Calcutta and Ahmadabad Electricity Supply companies stopped to play any role in this sector.

The Act envisaged five bodies for the development of power in the country:

(i) The Central Electricity Authority which was given the responsibility to develop a sound, adequate and uniform national power policy and to co-ordinate the activities of various planning agencies.

(ii) The State Electricity Boards, with responsibility for interconnections by main transmission lines and for supplying electricity,

(iii) State Electricity consultative councils to advise the State Electricity Boards on major aspects of policy,

(iv) Local advisory committees which might be set up by the State Governments.

(v) Tariff committees which might be appointed by State Government to examine the prices charged for the supply of electricity.

6.2 STATE ELECTRICITY BOARDS

The Electricity (Supply) Act of 1948 laid down that a sound, adequate, and uniform national policy should be developed coordinating the activities of planning agencies in relation to control and utilization of national power resources. It was in accordance with this Act that autonomous electricity boards were set up in all the eighteen States except in some north-east areas and the Union Territories. These boards were entrusted with the responsibilities of promoting the coordinated development of generation, transmission, and distribution of electricity within the State in the most efficient and economical manner. They were required to devote particular attention to power development in areas not being served or adequately served with electricity by any licensee.

The State Electricity Boards were given much more effective authority by the Act.The Boards are given authority to build, operate power system and sell electricity to the public, but they require govenment direction in investment and tariff policy. Gradually and steadily most of the State Electricity Boards have taken over complete power structures in the States.

At present the State Electricity Boards are charged with the following general duties.

(a) To arrange, in accordance with the generating company or generating companies if any, operating in the state, for the supply of electricity that may be required within the state and for the transmission and distribution of the same in the most efficient and economical manner with particular reference to those areas which are not for the time being supplied with electricity.

(b) To exercise such control in relation to the generation, distribution and utilization of electricity within the State as is provided for under or by the Act.

(c) To supply electricity as soon as practicable to a person requiring such supply, if the Board is compotent under this Act to do so.

(d) To collect the data or the demand for, and the use of electricity and to formulate coordinated perspective plans for the generation, transmission and distribution of electricity within the State.

(e) To prepare and carry out schemes for transmission, distribution and generation for promoting the use of electricity within the State.

(f) To operate the generating stations under its control in coordination with other agencies.

"The amendment of 1948 Act (in 1978) provided for financial strengthening of the Boards. They enable State Governments to convert outstanding debts accrued to them into equity. They also have reversed the priority of liabilities so that, in effect, cash outlays such as debt servicing must be honoured before transfers such as those to depreciation and general reserve. Moreover, the Boards are new required to generate a surplus after meeting all expenses properly chargeable to revenues, including operation and maintenance expenses, taxes, depreciation and interest". (Taylor, C. 1979).

State Electricity Boards play a major role in our country's power policy. The power supply industry is presently owned and operated mainly by State Electricity Boards. In the States where they exist they are mainly responsible for supply of power to the ultimate consumers.

6.3 CENTRAL ELECTRICITY AUTHORITY

The Electricity (Supply) Act, 1948 also envisaged creation of Central Electricity Authority under the Central Government with the responsibility to develop a sound, adequate and unifrom National Power Policy and co-ordinate the activities of the various planning agencies. A statutory organisation, the Central Electricity Authority remained only a part time body and its functions were being discharged by the Central Water and Power Commission (power wing) till 1974. With the setting up of a separate Department of Power, the Central Electricity Authority become a full time body dealing with national power policy planning since 1974. It helps not only in developing a national power policy and framing the plants of power development, but also through its technical examination of projects, it helps to utilize resources to their maximum level. The principal functions of the Central Electricity Authority are:

(i) formulation of short term and perspective plants for power development,

(ii) techno-economic appraisal of power projects,

(iii) advise State Governments, Electricity Boards, Generating Companies and other agencies on operation and maintenance of the power system in an efficient and cordinated manner and monitor their performance,

(iv) monitor the progress of schemes under implementation and assist in their timely completion.

(v) render consultancy services in different areas of electricity,

(vi) promotion of research in matters relating to electricity,

(vii) collection of data on generation, distribution and utilisation of power, study of costs, efficiency, losses and benefits, etc.

The Electricity (supply) Act, 1948 stipulated submission of all the power development schemes exceeding a capital expenditure of Rs. one crore to the Central Electricity Authority for its concurrence.

This limit,however has now been raised to Rs. five crores from 1984 by amending Electricity (supply) Act.

The Central Electricity Authority carries out detailed techno-economic appraisal of the schemes to ensure that they are consistent with the over all objectives of power development and represent the optimal option for meeting the requirements of power in the time-frame envisaged. Formal concurrence to projects is given by the Central Electricity Authority after the Planning Commission accord their approval for inclusion of projects in the plan.

Central Electricity Authority consists of a chairman who is assisted by five full time members. The organisation is divided into six different Deparments. The first two, the Thermal Wing and Hydro-generation Wing, help the projects to draw up techno-economic report. They also render their services in design and engineering to both types of power projects as well as monitor these projects under construction.

The power system wing is responsible for the planning and design of high voltage transmission system. It also helps in distribution, thus integrating the state and regional power system operations. Like the Hydro and

Thermal wings, it monitors the progress of transmission and distribution projects under construction.

The operation and monitoring wing is responsible for monitoring the performance of both thermal power stations and hydel power stations as well as monitoring the transmission and distribution of power. In addition, there are four training institutes for thermal power station personnel under this department.

The Economic and Commercial Wing deal with the commercial, legal, and economic aspects of the power sector and is also responsible for the inspection of electrical installations under the Government of India.

The Planning Wing of Central Electricity Authority has much wider role to play. It is in charge of planning for power development including the indentification of power resources and their maximum development, load forcasting and the techno-economic reports of all power generation transmission and distribution schemes of all units in its initial stages.

Apart from these wings, the Central Electricity Authority also has a Consultancy Wing which deals with design and engineering services of hydro, thermal and power systems. It gives consultancy in this area to the State Electricity Boards on a time cost basis.

Thus Central Electricity Authority performs both policy planning and technical services. It deals with broad issues of planning and solving of specific problems associated with the power sector. Its main function is the development of national power policy. The power planning is a long term process which takes usually around 10-15 years. It is the guiding force of the power sector and has an important role to play in its development. Therefore, it influences the power structure in every possible way. It collects and records data regarding generation and distribution of power.

The Central Electricity Authority provides assistance in the development of manpower organisation. It makes arrangements for improving the skills of persons working in the generation and supply of electric power. Thus its responsibilities also include research and development in regard to personnel policies.

The Central Electricity Authority has become an important body in the power structure because it deals with policy planning, supervision, consultancy, coordination and research. Its functions have been increasing over the years and both the State and Central Government have used the body to the optimum.

6.4 DAMODAR VALLEY CORPORATION

The Damodar Valley Corporation (DVC) was established in 1948 by the Central Government, the Damodar Valley Corporation is based on the pattern of Tannesses Valley Authority (U.S.A.) It is a joint venture by the Government of India, West Bengal, and Bihar. It is a multipurpose project and an autonomous body which is responsible for the integrated development of the Damodar Valley in relation to irrigation, flood control, generation and sale of electric power, both hydro and thermal, to bulk consumers including TISCO.

6.4 TUNGABHADRA BOARD

Like Damodar Valley Corporation Tungabhadra project is a multipurpose project, it was set up in 1953 under the Andhra Pradesh State Act. It is responsible for generation of electricity in the Tungabhadra Dam and the Hampi power station. This power goes to the States of Andhra Pradesh and Karnataka. The board also looks after the maintenance of transmission systems. All policy planning and execution concerning generation and distribution of this system is done by the Board.

6.6 BHAKRA-BEAS MANAGEMENT BOARD

This board was established in 1967 under the control of the Central Government, it manages the Bhakra Nangal and Beas projects and transmission system. It has a full time chairman and six part-time members representing Punjab, Haryana and the Central Government. It has two wings of irrigation and power each of them consists of a full time member. This board also has a financial adviser.

6.7 NAYVELI LIGNITE CORPORATION

This Corporation was set up in 1956 under the Companies Act. It is a public sector undertaking. It controls both the open cast lignite mines and its associated thermal power station in Tamil Nadu. It is managed by a board of directors constituted by a chairman, two directorsand six part-time directors.

6.8 KARNATAKA POWER CORPORATION

This corporation is set up in Karnataka. This organisation is regulated by the State and not by Central Government. It has a board of directors with a Chairman and a full time managing director.

6.9. NORTH-EASTERN ELECTRIC POWER CORPORATION

It was established by the Department of Power in 1976 to develop the electric power sector in the backward region of the North-east. This Corporation is in the central sector. Its main functions are the construction, generation, operation, maintenance, transmission, distribution and sale of power in north eastern region. This corporation also has a board of one full time chairman-cum-managing director and twelve part-time directors.

6.10 THE DEPARTMENT OF ATOMIC ENERGY (DAE)

Under the Atomic Energy Act of 1962, the sole responsibility of nuclear power development for electricity generation is vested with the Central Government. The function of establishing nuclear power plants and their operation is being discharged by the Department of Atomic Energy. It was provisionally headed by a Secretary with its main function being policy planning. With the passage of time it has acquired enough power and autonomy to not only lay down policy, but execute it as efficiently as possible.

At present it can design, erect, commission and operate atomic power plants. It has developed its own fuel fabricating and heavy water plants and fuel disposal units. At present the Department is operating four atomic power plants including Tarapur, Rajasthan, Kalpakkam and Narora.

The operation of all atomic power plants are carried out by Atomic power Authority, a constituent of the Department of Atomic Energy. It is responsible for the management of nucler power stations and the bulk sale of electricity generated by these plants.

6.11 REGIONAL ELECTRICITY BOARDS

In the early sixties the advantage of integration of power systems at the regional level and the limitation of state as a spatial unit for power planning and operation was recognised. It was considered necessary to adopt regional approach in power planning and the operation of power systems in order to achieve economies in power supply. To promote such an approach the country was divided into five convenient regions and regional electricity boards were created through Central Government resolution in 1964. The five regional electricity boards are -

NORTHERN REGION - Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Rajasthan, Uttar Pradesh, Chandigarh and Delhi.

WESTERN REGION - Gujarat, Madhya Pradesh, Maharashtra, Goa, Daman and Diu, Dadra and Nagar Haveli.

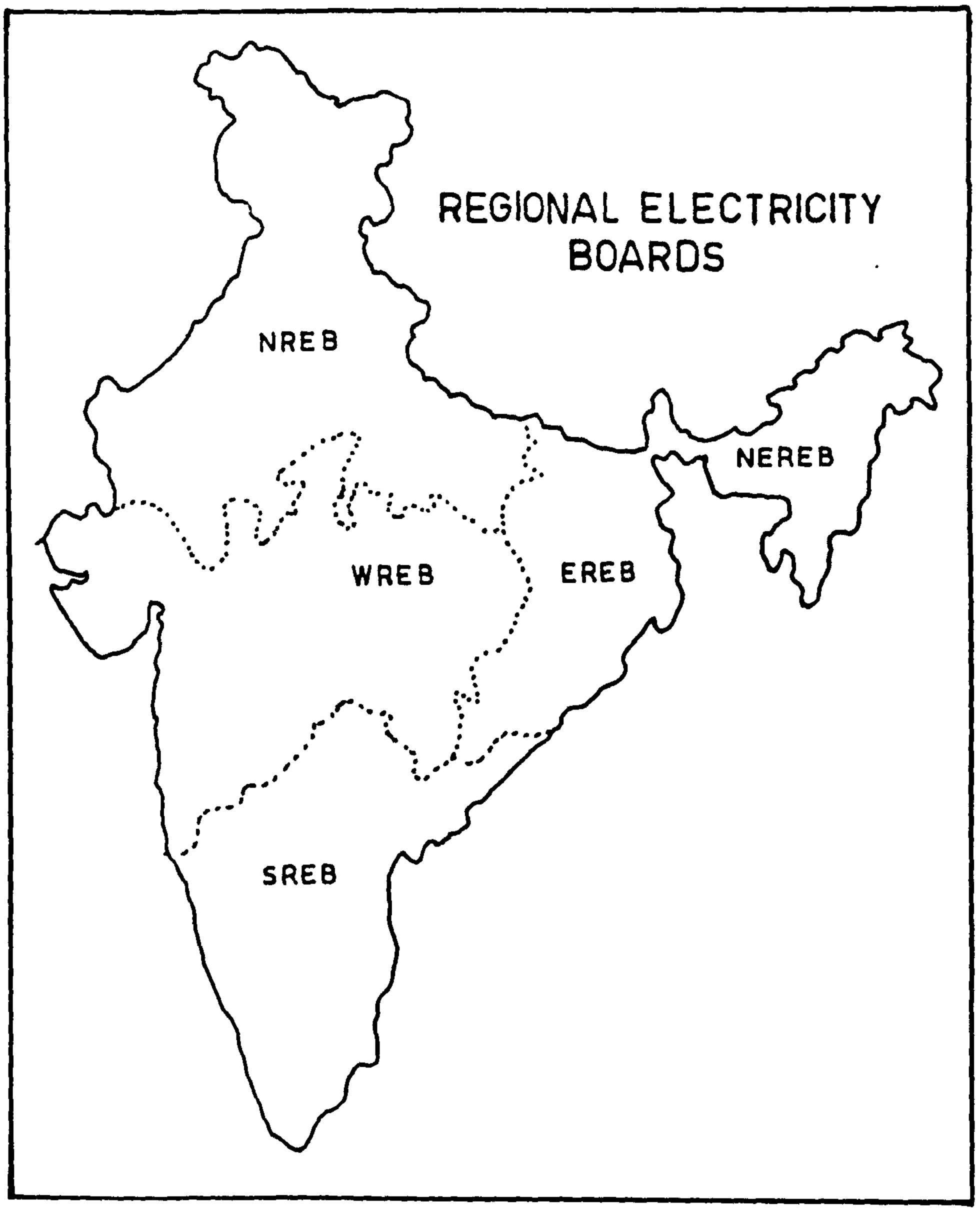
SOUTHERN REGION - Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Pondichery.

EASTERN REGION - Bihar, Orissa, Sikkim and West Bengal.

NORTH EASTERN REGION - Assam, Manipur, Meghalaya, Tripura, Arunachal Pradesh and Mizoram.

The Regional Electricity Boards are charged with the responsibility of coordinating the operation of power supply industry in the five regions. This enables the power structure to be more efficient because while planning electric power generation, full advantage could be taken of the resources available in the region as a whole.

The functions of Regional Electricity Boards include : reviewing progress of projects in their regions, planning integrated operation among the State systems, preparing coordinated maintenance schedules for their regions, determining the availability of power for inter-state transfer, prescribing generation schedules, and determining a suitable tariff for inter-state exchange of power.



Map. 6·1

Since inter- connected systems require less generating capacity due to diversity in daily peak demands, larger and more efficient units can be installed in the region. With the result higher voltage transmission lines can be made available which has lower losses. These boards can make generation schedules to utilize optimum available capacity. Besides this, these Boards can coordinate the maintenance schedule for generating plants and can help the power sector to economise in this area and enable the plant to work efficiently with less outages.

" The Regional Electricity Boards constitute the leading edge of structural change needed to integrate the operation of India's power systems. Their future evolution will be critical to the effort to improve the efficiency of the power sector through the realization of economies of scale."(Taylor, C. 1979).

6.12 RURAL ELECTRIFICATION CORPORATION

Rural electrification has been a priority area in power development in India. As the benefits of electricity supply was realised the State Electricity Boards started electrification of rural areas as well as urban. In the beginning electrification simply meant power for household purposes in rural areas. With the result power generation and power consumption was confined to a small sector. During the mid sixties due to food shortage, the Government of India had reviewed its policy on rural electrification. New diversification had taken place in the form of pump energisation to increase agricultural production.

In 1969, the Rural Electrification Corporation (REC) was established as a public sector undertaking. The main objective of this Corporation is to finance rural electrification schemes and promotion of rural electrical cooperatives all over the country. With the financial help from the commercial banks and the Agriculture Refinance and Development Corporation (ARDC) the Corporation has financed large scale agricultural schemes in regard with energisation of pumpsets. Now its main emphasis is on the development of undeveloped and tribal areas. The Pending policies of Rural Electrification Corporation are governed by the guidelines laid down by the Department of power. The basic directives emphasise that the Corporation coordinate development of rural electrification as well as development of rural infrastructure in rural areas to ensure the effect of rural electrification on agricultural production. The directives also require that Rural Electrification corporation adopt an area development approach with emphasis on an under-developed areas.

6.13 NATIONAL THERMAL POWER CORPORATION

In 1976 the Electricity (supply) Act 1948 was amended to provide for establishment of generation companies under the authority of Central Government.The national companies namely the National Thermal power corporation (NTPC) and National Hydro Power Corporation were established. The National Thermal Power Corporation was given the authority to establish regional thermal power stations and made responsible for bulk transmissions from these units to the state power system. The National Thermal Power Corporation is given the charge of planning, promoting and organizing thermal power sector. The National Thermal Power Corporation is supposed to investigate new sites, prepare project reports, construct, operate, generate and maintain transmission and distribution of power generated from thermal units. It also undertakes research and development in thermal power.

The National Thermal Power Corporation has evolved its own management techniques in engineering, construction, finance, materials etc. It has been expanding its area of work.

The national Thermal Power Corporation has been able to install super thermal power projects in various regions within a short period of time. The main objectives of NTPC are -

* To establish thermal power capacity and associated transmission system within prescribed time schedule, cost and reliability level and conforming to the National Energy Plan.
* To operate its power stations at base load with maximum performance efficiency and plant reliability.
* To build in house capabilities so as to be self-reliant in respect of technical expertise and develop a cadre of skilled man-power with a knowledge of the latest technology.
* To manage the financial operations of the company in accordance with sound commercial utility practices and to generate returns as per Government guidelines.
* To develop and implement a well knit personnel policy and a comprehensive personnel programme that will be result oriented and to develop an organisational culture which motivates employees to contribute their best towards the achievements of organisational objectives.
* To function as a responsible public sector undertaking bearing in mind its commitment to the society.

At present, the National Thermal Power Corporation is carrying out the construction and operation of nine super thermal power projects, four combined cycle gas based projects and two transmission projects with a total approved capacity of 15767 MW and about 20200 circuit kilometers of associated 400/220 Kv transmission lines, widely extended all over India.

The total installed capacity of National Thermal Power Corporation's power station increased to 10125 MW in 1991 which constituted about 16 per cent of the total capacity spread all over the country. The National Thermal Power Corporation started with an approved investment of Rs. 6660 crores and authorised capital of Rs. 2500 crores in 1976-77, it stood at Rs. 18,500 cores and Rs. 8000 crores of approved investment and authorised capital respectively in 1991.

6.14 NATIONAL HYDRO ELECTRIC POWER CORPORATION

The National Hydro Electric Power Corporation (NHPC) was established in 1976 to set up major hydro electric projects on regional and national considerations. The main objectives of National Hydroelectric Power Corporation are to plan and organise integrated development of hydro-electric power. The gamut of National

Hydro-electric Power Corporation activities includes investigation, planning, design, construction, operation and maintenance of hydro electric power projects and Extra High Voltage transmission systems. The Corporation is fully equipped to execute hydro-electric projects and transmission lines logistically in difficult Himalayan terrains. The paid up capital of the Corporation was Rs.165.50 crores in 1984 which had increased to Rs.2080.13 crores in 1992.

The National Hydro Electric Power Corporation is responsible for the operation and maintenance of the following hydro-electric power stations commissioned by them.

(i) Baira Siul Power Station in Himachal Pradesh with 180 MW capacity.

(ii) Loktak Power Station in Manipur with 105 MW capacity.

(iii) Salal (Stage-1) Power Station in Jammu and Kashmir with 345 MW capacity.

(iv) Tanakpur Power Station in Uttar Pradesh with 120 MW capacity.

Besides four operational power stations, the construction of the following power stations is in an advanced stage.

* Dul Hasti hydro electric project in jammu and Kashmir with 390 MW capacity .

* Chamera hydro electric project (Stage-1) 540 Mw capacity in Himachal Pradesh.

* Uri hydro electric project in Jammu and Kashmir with 480 MW capacity.

* Salal hydro electric project (Stage-II) in jammu and Kashmir with 345 MW capacity.

* Swalkot hydro electric project in Jammu and Kashmir with 600 MW capacity.

* Baglihar hydro electric project in Jammu and Kashmir with 450 MW capacity.

* Ranjit hydro electric project in Sikkim with 60 MW capacity.

Besides, National Hydro-electric Power Corporation has completed investigation on five projects totalling 860 MW with a high degree of technical accuracy based on experience gained on earlier projects investigated in collaboration with Swedish and Canadian firms.

The Corporation plans to add 1455 MWs capacity through 5 projects during the Eighth Five Year Plan period. The NHPC has drawn up a perspective plan to achieve 7835 MW through 17 projects by the turn of the century.

6.15 DEPARTMENT OF POWER

The Department of power was created in 1974 by the Ministry of Energy. Before this, all matters relating to power came under the Ministry of Irrigation and power which could no longer remain together as thermal, and nuclear generating units increased for more power generation. The Department of Power is responsible to Parliament for laying down national policy planning for the development and regulation of the power resources in India. The technical aspects of the power sector are met by the Central Electricity Authority, under the Department's guidance and authority.

The Department is also responsible for national policy planning for regulation and conservation of the country's total power resources. All national responsibility of formulating and promoting power sector is given to this Department. It controls the central autonomous corporate and statutory bodies of the power sector and coordinates the activites of the various agencies within the sector, the National Thermal Power Corporation, National Hydro electric Power Corporation and Rural Electrification Corporation. It coordinates Relations between the centre and States, research and development activities including the coordination and development of non-conventional sources of energy to generate power such as solar and tidal energy. The Department also looks after the efficient working of thermal units especially in regard to supply of coal. It also manages energy supply in the Union Territories and executes central projects.

The Department is headed by a Secretary and four joint Secretaries. The division of the Department into different wings was done to carry out its work under policy planning, cordination, administration and research and development. The Department also has a fifth wing headed by a Financial Advisor. The Financial Advisory wing advices the Ministry regarding investment and expenditure in the central sector. It also negotiates with financial bodies for the necessary requirement of capital for establishing power project.

This organisation which heads the power sector is flexible in its attitude. This permits it to deal with both long term and short term problems. Since it is the coordinating body it has vast powers. Thus, while the Department is not directly involved in the operation of power plants, it does look after both short-term and long-term problems of the power sector which ranges from policy planning to the operation of the plant.

Since it is the apex body in the power sector, its role is central in initiating and coordinating the activities of the organisation throughout the power sector in the country.

6.16 POWER FINANCE CORPORATION

The Power Finance Corporation was set up in 1986. It was established under the control of the Department of power, with the main objective of providing term finance for power projects.

The authorised share capital of the corporation is Rs. 1,000 crores. The paid up capital is Rs. 330.40 crores. The Corporation has sanctioned loans for 75 proposals involving a loan assistance of Rs. 594.86 crores for renovation and modernisation of thermal power stations, transmission and distribution facilities.

6.17 POWER GRID CORPORATION

Power Grid Corporation was established in 1989 for carrying out the construction of high voltage transmission lines, sub-stations, load despatch centres and communication facilities in an efficient and coordinated manner, to transfer electric power from generating plants to load centres. The World Bank has extended a loan of

US $ 350 million to power Grid Corporation for a power system development project. The project would make the power transmission system strong and help inter-regional and inter-state transfer of power possible.

Thus, it would be seen that the power sector in India has a complex organisational structure. The Department of power, the Central Electricity Authority and the State Electricity Board, constitute the core of the organisational structure at present. The National Thermal power corporation and the National Hydro-electric Power Corporation also emerge as key organisations for generation and bulk supply in the various parts of the country.

S U M M A R Y

The Structure of power industry as we see it today in India has emerged over a period of nearly hundred years. In 1910 the Indian Electricity Act was passed to govern the grant of licences for electricity generation and distribution. This Act of 1910 was more concerned with the regulatory and safety aspects of electricity than with the organisational structure of the industry itself. The organisational structure of power industry has emerged only after the Electricity (Supply) Act, 1948 was passed. After Independence the constitution of India put electricity in the concurrent list and it became possible for both the Union Government and state governments to legislate on the subject. The Electricity (Supply) Act, 1948 provided the establishment of a new statutory organisation, the Central Electricity Authority and the State Electricity Boards, which became the main supplying agencies for power through-out the country. In accordance with this Act the autonomous electricity boards were set up in all the eighteen states except in some north-east areas and the Union territories. These boards were enstrusted with the responsibilities of promoting the coordinated development of generation, transmission and distribution of electricity within the state in the most efficient and economical manner. The Central Electricity

Authority is responsible for the development of a sound, adequate and uniform national Power Policy and co-ordinate the activities of the various planning agencies. Under the Atomic Energy Act of 1962, the sole responsibility of nuclear power development for electricity generation is vested with the Central Government. A Department of Atomic Energy is responsible for the establishment and operation of the nuclear power plants. In the early sixties the advantage of integration of power systems at the regional level was recognised. It was considered necessary to adopt regional approach in power planning accordingly, the country was divided into five convenient regions and Regional electricity boards were established in 1964. In 1969, the Rural Electrification Corporation was established as a public sector undertaking. The main objective of this Corporation is to finance rural electrification schemes and promotion of rural electrical cooperatives all over the country. In 1976 the Electricity (Supply) Act, 1948 was amended to provide for establishment of generation companies under the authority of Central Government. The national Companies namely the National Thermal Power Corporation and National Hydro Power Corporation were established. The National thermal Power Corporation is given the charge of planning, promoting and orgnising the thermal power sector. The National Hydro Power Corporation is responsible to set up major hydro electric projects on regional and national considerations. The Department of power was created in 1974 by the Ministry of Energy. The Department is responsible to Parliament for laying down national policy planning for the development and regulation of power resources in India. It controls the central autonomous corporate and statutory bodies of the power sector and coordinates the activities of the various agencies within the sector. The Power Finance Corporation was set up in 1986 under the control of Department of Power, for providing term finance for power projects. Power Grid Corporation was established in 1989 for carrying out the construction of high voltage transmission lines, sub-stations and load despatch centres to transfer power from generating plants to load centres.

CHAPTER - VII

RURAL ELECTRIFICATION IN INDIA

Rural electrification has become a very important element for social and economic betterment in the developing countries.

"Rural electrification is comparatively a new field of investment in most of the developing countries. The allocation of resources increase with the rise in their gross national product with the result that investment in rural electrification rises with the rise in tempo of development programme" (Guru, D.D. 1987).

Rural electrification is essential for modernisation of rural areas, which provide food, industrial raw material, labour, etc. for other sectors of the economy.

In this chapter, an attempt has been made to throw light on rural electrification in India, Rural Electrification Corporation and investment incurred on village electrification. The development of electrification in villages and energisation of pumpsets has also been underlined.

7.1 IMPORTANCE OF RURAL ELECTRIFICATION

According to an American author C.T. Ellis, "Once dependable electricity is made available to rural people at a reasonable cost, the users of it are found rapidly progressing regardless of the state of development which already exists, and it pays itself many times over". It is clear that in rural areas electric power is one of the most important instruments which can increase economic development and agricultural production. Rural electrification has become an important infrastructure of development which makes villages more liveable and rural population more productive.

The Indian economy is predominantly a rural economy as nearly 80 per cent of the population live in villages and the bulk of the rural population is engaged in agriculture. Therefore, villages are the focal points of development and rural electrification plays an important role in the development of the Indian economy.

Electric power is very essential to rural development in the country as it serves a number of purposes such as agricultural and agro-industrial, domestic, and commercial.

Electric power makes it possible to maximise the use of underground water for irrigation. As water is the primary need of agriculture, underground water for irrigation is very essential for those areas where rainfall is not sufficient and supply of surface water is limited to achieve the optimum benefits of increased yields. Canal irrigation too has its limitations. India has substantial potential of underground water which still remains to be exploited. Out of the known underground potential around 40 per cent has been exploited. The most economical method of pumping out underground water is with the help of electric pumpsets. During the past few years energisation of a large number of pumpsets through rural electrification has boosted the agricultural production in the country.

A study conducted by Planning Commission in 1965 revealed that as a consequence of the installation of electric pumpsets on existing irrigation works, the area irrigated increased by 66 per cent for both Kharif and Rabi crops. The average area irrigated per household increased by 60 per cent from 6 acres to 9.6 acres and substantial modernisation in cultivation practices also took place. Existing crops were more extensively cultivated, new crops were introduced and intensity of irrigation increased. Electric pumps have generally provided much needed insurance for the Indian farmers against the vagaries of monsoons.

Rural electrification in India has become synonymous with the energisation of pumpsets, increased agcricultural production and economic development in rural areas. Rural electrification also plays an important role in the growth of rural indsutries. With the introduction of electricity, traditionally operated industries switched over the use of electric power. Electric power reduces labour and fuel costs and increases productivity. It also expediates the introduction of agrobased industries and small scale industries in rural areas.

Rural Electrification has brought a basic change in the life style of rural masses. It has provided modern amenities of life like light, fan etc. in villages. A research study conducted by the Operation Research Group (1979) brings out a close relation between electrification of a village and the spread of radios and cinemas as a source of entertainment, improved working conditions in farms, workshops, schools, dispensaries and shops and increase in available working hours etc. The shift from mannual to power driven pumpsets was found to reduce the time required for irrigation from 8 to 4 hours per acre giving the farmers greater time to pursue other occupations or enjoy some leisure.

Thus, rural electrification is not only an important infrastructure and input for the economic development of the rural areas but also plays a great role in social transformation.

7.2 RURAL ELECTRIFICATION IN INDIA

There was no policy for rural electrification in India before Independence. As a planned programme rural electrification was started around fifties in the country. In 1951 Tamil Nadu, Kerala and Karnataka had around 10,9 and 2 per cent of electrified villages respectively. The other states had less than 1 per cent electrified villages. In the early years of planning, electric power for rural areas was treated as a special amenity rather than as an input into agriculture and industry. During the First Five Year Plan rural electrification was confined to a few states. During the Second and Third Five Year Plans it was extended to all states. However, the progress made upto late 1960's was not satisfactory. At the end of the Third Five Year Plan electric power had reached only about 45,000 villages out of a total of 5.76 lakhs. the total number of pumpsets energised in the country was 5 lakhs at that time.

India experienced a severe drought period from 1965 to 1967. After the drought period, emphasis was being laid on energisation of pumpsets to increase agricultural production. It was realised that dependence on monsoon will not help agriculture and as a result rural electrification programme was reoriented towards energisation of pumpsets for irrigation facilities. The outlay on rural electrification during the five year period from 1966-67 to 1970-71 was nearly Rs. 450 crores. By 1971, the number of villages electrified was about 1 lakh and the number of pumpsets energised had increased to about 16 lakhs. During the Fourth Plan, energisation of pumpsets were given high priority. At the end of the plan period the total number of villages electrified and wells energised increased to 1,56,729 and 24,26,133 respectively. During the Fifth Plan, the Rural Electrification programme was integrated with the Minimum Needs Programme and a target of covering at least 40 per cent of the rural population in each state was adopted. At the end of the plan, the number of electrified villages reached to 2,50,112 and wells energised to 39,49,120.

The Minimum Needs Programme for rural electrification to benefit hilly,tribal and backward areas was given top priority during the Sixth and Seventh Five Year Plan. By the end of the Seventh Five year plan, nearly three-fourth of the villages had been electrified, which resulted in energisation of around 80 lakhs electric pumpsets to meet the irrigation needs of farmers. Rapid augmentation of underground irrigation facilities resulted in manifold increase in agricultural production.

7.3 RURAL ELECTRIFICATION CORPORATION

Rural Electrification Corporation (REC) came into existence in July 1969 as a Government owned company with the primary objective of promoting extension of power supply to rural areas and financing of rural electrification Schemes throughout the country. It aimed to administer the funds provided as Central sector outlay for rural electrification in India, on one hand and on the other to provide the needed direction and impetus to the concept of integrated rural development through massive exploitation of ground water resources and promoting rural industries. The Corporation is also empowered to raise resources by way of grants, loans, advances from other sources such as State Government, Companies, Banks, Trusts of Individuals.

The main objectives of the Corporation are:-

(i) To finance rural electrification schemes in the Country,

(ii) To promote and finance rural electricity Co-operatives in the Country through direct loans or otherwise, and

(iii) To subscribe to special rural electrification bonds on conditions to be stipulated from time to time. The Corporation's assistance are thus mainly by way of

(a) direct loans to Electricity Boards for specific viable rural electrification schemes approved by the Corporation,

(b) direct loans or otherwise to rural electric co-operatives, and

(c) subscription to rural electrification bonds of State Electricity Boards issued with the approval of and on terms and condition stipulated by the Corporation.

Besides funding viable schemes and subscribing to Rural Electrification Bonds issued by State Electricity Boards, the Rural Electrification Corporation guides and assists State Electricity Boards in identification and formulating schemes for different consumer groups.

appraises such schemes, offers technical guidance and monitors physical and financial progress of the scheme.

According to Central Government directives, the corporation is required to -

(i) establish sound policies and procedures for consideration, approval and implementation of rural electrification schemes to be financed by it,

(ii) develop and apply criteria for establishing priorities as regards the choice of the scheme on the basis of economic viability, and

(iii) adopt a project approach so that extension of electricity along with other investments results in increased agricultural production in the area.

Thus Rural Electrification Corporation is also responsible for ensuring that the projects it undertakes do not result in financial losses to the State Electricity Boards. Therefore, it is important that the projects generate enough surplus to pay the costs and gives a reasonable return on investment. The Corporation also provides special categories of loans to suit the requirements of backward, hilly, tribal and desert areas. To energise a large number of pumpsets a 'special project Agriculture Programme' has been started with the joint venture of REC, Agricultural Refinance and Development Corporation and Commercial Banks. Since 1969, the Rural Electrification Corporation has made tremendous contribution in increasing the pace of rural progress through the extension of electricity. The Corporation has been working in a very scientific and systematic manner from the very beginning. It has performed the critical task of promoting and financing rural electrification throughout the country.

Table 7.1 shows number of projects approved by Rural Electrification Corporation and amount of loan sanctioned by it.

For improving the quality of rural life and to make village electrification useful for rural people, the Rural Electrification Corporation had launched a special drive for promotion of rural households electrification during 1989-90. About 4.30 million rural households connections were released under this special programme till 1991-92. During 1991-92 about 3.99 lakh pumpsets were energised with the assistance of Rural Electrification Corporation, out of this 2.94 lakh

TABLE - 7.1

LOANS SANCTIONED AND DISTRIBUTED BY REC

Year	No.of projects approved	Financial assistance sanctioned (Rs. in lakhs)
1970-71	96	6,405
1971-72	116	6,534
1972-73	227	9,542
1973-74	246	7,588
1974-75	375	13,964
1975-76	288	11,822
1976-77	337	10,491
1977-78	397	14,514
1978-79	717	23,066
1979-80	776	21,142
1980-81	1035	26,344
1981-82	836	20,920
1982-83	1125	34,268
1983-84	1515	46,705
1984-85	1802	51,490
1985-86	1454	33,074
1986-87	2171	67,791
1987-88	3104	1,02,787
1988-89	2281	97,199
1989-90	2361	98,485
1990-91	1990	96,183
1991-92	1320	95,415

Source: Rural Electrification Corporation, Bulletin 1991-92.

pumpsets were energised under Special Projects Agriculture programme.

The Corporation has been endeavouring to promote and finance RE Cooperatives consisting of farmers and others in villages so as to hasten the implementation of rural electrification programme and distribution of power in these areas. During 1991-92, the Corporation approved an additional financial assistance of Rs. 14.94 crores of project loan to existing RE Cooperatives Societies as Rs.0.60 crore to the State Government for contribution to share capital, making the total financial assistance of Rs. 132.22 crores to these Societies. Presently 39 RE Cooperative Societies are operational under which 4103 villages and 1635 hamlets stood electrified by 1991-92.

The Rural Electrification Corporation also pays special attention on standardisation of equipments, materials and construction practices and also on introduction of innovative and cost effective technologies in rural distribution works.

7.4 OUTLAYS ON RURAL ELECTRIFICATION

The outlays on rural electrification have increased with more emphasis being laid on it in each successive five year plan. Table 7.2 indicates Investment on rural electrification during five year plans.

TABLE - 7.2

INVESTMENT ON RURAL ELECTRIFICATION

(Rs. in Crores)

Period	Financial outlay for Power sector	Investment on Rural Electrification
First Plan	260	8
Second Plan	460	75
Third Plan	1252	153
Three Annual Plans	1209	237
Fourth Plan	2932	819
Fifth Plan	5244	842
Sixth Plan	15112	1699
Seventh Plan	34273	2108

Source: Planning Commission

The investment for rural electrification in First and Second Plans was very less though some Central assistance to State was provided for expansion of power facilities to increase employment opportunities. The actual expenditure during the First Plan was Rs. 8 crores while in the Second Plan it was Rs.75 crores. Rural electrification was given high priority from the beginning of the Third Plan. The provision of Rs. 153 crores was made for rural electrification during this plan. As a result of the investment made during the plan, 23,394 villages were electrified and more than 3 lakh pumpsets were energised.

Due to severe drought period in 1965 and 66 emphasis was laid on energisation of pumpsets along with village electrification during the three annual plans. During these plans an investment of Rs.237 crores was made on rural electrification, consequently 28,588 villages were electrified and 5.76 lakh wells were energised. Rural electrification was given high priority in the Fourth Plan also. Due to increased investment, number of villages electrified reached to 1,56,729. During the Fifth and Sixth Five year Plan rural electrification occupied high priority. The emphasis was on Minimum Needs programme during these plan periods. The objective of village electrification under this scheme was to make available basic amenities in rural areas. Special schemes were started to provide electric power in remote and interior areas of the country.

7.5 ELECTRIFICATION OF VILLAGES IN INDIA

The programme of rural electrification has gained prominence in India not merely to bring about a change in the life style of rural masses but because electric power is the most vital instrument for economic development and increased agricultural production. Nearly three fourths of the villages have already been electrified which has resulted in energisation of around 80 lakh of electric pumpsets to meet the irrigation needs of farmers.

Table 7.3 shows number of villages electrified in India since 1950-51. It is clear from the table 7.3 that rural electrification has continuously been increasing in the country. It was recorded at about 4.78 lakhs village electrification in 1990-91 as compared to 0.03 lakhs village electrification in 1950-51. Rural electrification has increased from 0.5 per cent in 1950-51 to 83 per cent in 1990-91 which is an impressive progress during this period.

7.6 STATEWISE RURAL ELECTRIFICATION

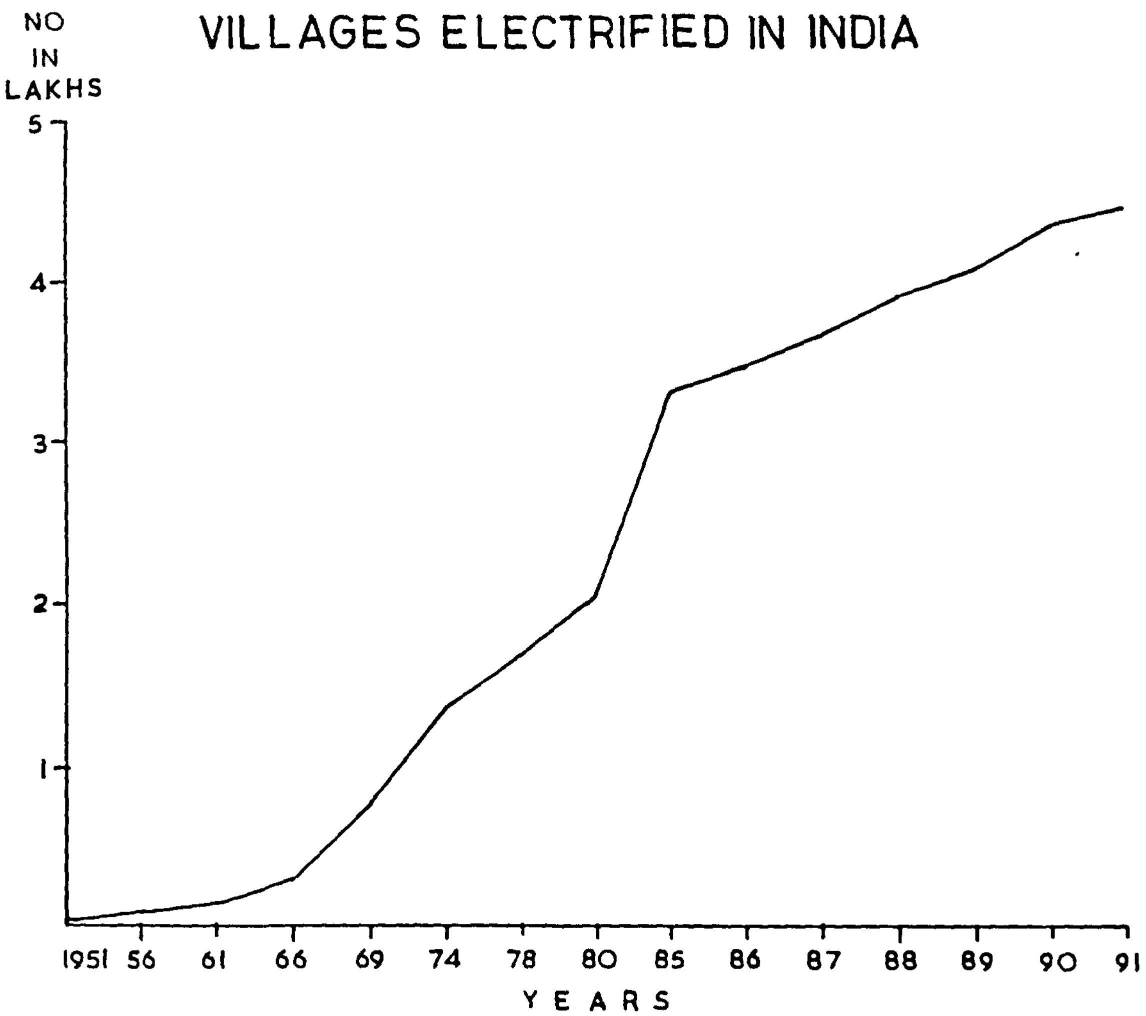
State-wise rural electrification shows that electrification programme has been uneven among states and Union territories, while some states have achieved cent per cent rural electrification in their respective

TABLE - 7.3

VILLAGESELECTRIFIED: 1950-51 TO 1990-91

Year	No.of Villages electrified (in lakhs)	Percentage
1950-51	0.03	0.5
1955-56	0.07	-
1960-61	0.21	3.8
1965-66	0.45	-
1968-69	0.73	17.5
1973-74	1.86	-
1977-78	2.16	-
1979-80	2.49	47.3
1984-85	3.70	60.3
1985-86	3.90	67.7
1986-87	4.14	71.2
1987-88	4.35	75.2
1988-89	4.55	78.7
1989-90	4.70	81.3
1990-91	4.78	83.1

Source: Annual Report, 1990-91, Department of Power, Ministry of Energy, Government of India, New Delhi.



VILLAGES ELECTRIFIED IN INDIA
NO IN LAKHS
5
4
3
2
1
1951
56
61
66
69
74
78
80
85
86
87
88
89
90
91
YEARS

Fig. 7.1

territories, others lag behind. Table 7.4 shows state-wise rural electrification.

Table 7.4 reveals that in eight states of Maharashtra, Andhra Pradesh, Gujarat, Himachal Pradesh, Punjab, Haryana and Kerala 100 per cent rural electrification has been achieved. Several other states have achieved more than 80 per cent rural electrification. Rural electrification programme has made tremendous progress in the states during the planning period as it is clear from table 7.4. The remarkable feature of the growth of rural electrification is that it has been more intense in the small states like Haryana, Punjab, Kerala, Karnataka, Gujarat, Himachal Pradesh, Tamil Nadu than to the larger states of Uttar Pradesh, Bihar, West Bengal and Rajasthan. States of Eastern Region have very low percentage of rural electrification compared to other states of the North Western, Southern and Western states which results in higher per Capita income in the prosperous States of these Regions.

TABLE - 7.4

STATEWISE RURAL ELECTRIFICATION

State/Uts	Villages Electrified (in thousand)	Percentage Electrified
Uttar Pradesh	81.48	72
Madhya Pradesh	62.23	87
Bihar	46.72	69
Maharashtra	39.10	100
Orissa	31.38	67
West Bengal	27.58	73
Andhra Pradesh	27.35	100
Rajasthan	27.91	77
Karnataka	26.48	100
Assam	21.29	97
Gujarat	17.48	100
Himachal Pradesh	16.76	100
Tamil Nadu	15.81	99
Punjab	12.34	100
Haryana	6.74	100
Jammu & Kashmir	6.15	195
Tripura	2.82	60
Meghalaya	2.27	46
Manipur	1.48	73
Arunachal Pradesh	1.42	44
Kerala	1.21	100
Nagaland	1.09	99
Mizoram	0.45	63
Sikkim	0.04	92
Goa	0.37	100
UTS	1.12	100

Source: Annual Report 1990-91, Dept. of Power, Ministry of Energy, Govt. of India, N. Delhi.

7.7 ENERGISATION OF PUMPSETS

Energisation of pumpsets/tubewells in the villages were started due to enormous potential of ground water resources in India. Rural Electrification Corporation undertook the task of energisation of pumpsets under a national programme known as 'Special Project Agriculture' which plays an important role in providing timely crops with the operational control in the hands of farmers. This programme has benefitted farmers who are affected by monsoon failure. In the wake of drought, the REC has established large number of pumpsets and their energisation to provide electricity to rural areas in times of monsoon failure.

"A study conducted by the National council of Applied Economic Research on Socio-economic benefits which the rural area can derive from electrification and energisation shows that there is an increase on an average of 7.63 acres of gross irrigated areas per user of pumpsets and the additional income derived from works out to Rs. 237 per cultivated acre. A farmer using electrified pumpsets served about 337 days of family or hired labour value at Rs. 1017. On an average, a pumpset saved 354 bullock labour days per crop year, the average saving of which work out to be Rs. 712".

TABLE - 7.5

PUMPSETS ENERGISED: 1950-51 TO 1990-91

Year	Pumpsets Energised (Nos.)
1950-51	21,008
1960-61	1,98,904
1970-71	15,71,000
1980-81	43,30,437
1981-82	46,59,033
1982-83	49,73,268
1983-84	53,08,668
1984-85	57,08,563
1985-86	61,51,975
1986-87	66,56,541
1987-88	72,25,791
1988-89	78,19,049
1989-90	83,58,363
1990-91	89,09,110

Source: Current Energy Scene in India, CMIE, May 1992.

Table 7.5 shows energisation of irrigation pumpsets/Tubewells in the country from 1950-51 to 1990-91.

It is evident from table 7.5 that the number of pumpsets energised increased tremendously in the country. The number of energised pumpsets were merely 21,008 in 1950-51, it increased to 89,09,110 in 1990-91. Agricultural output and potentiality of agro -based industries have increased due to availability of dependable means of irrigation.

7.8 STATEWISE ENERGISATION OF PUMPSETS

The comparative position of energisation of pumpsets in different states has been presented in table 7.6.

In the energisation of wells Maharashtra stands first and Tamil Nadu second. Table 7.6 reveals that small number of pumpsets have been energised in Bihar, West Bengal, Orissa and Rajasthan while Maharashtra, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Karnataka, Uttar Pradesh and Punjab have large number of energised pumpsets. The North Eastern States of Assam, Arunachal Pradesh, Meghalaya and Nagaland always have sufficient monsoon so they do not require large energised pumpsets network.

TABLE - 7.6

STATE-WISE ENERGISATION OF PUMPSETS

States	No.of Pumpsets/Tubewell (in 0000)
Maharashtra	160.750
Tamil Nadu	131.867
Andhra Pradesh	116.540
Madhya Pradesh	87.871
Karnataka	72.300
Uttar Pradesh	74.925
Punjab	60.182
Gujrat	46.039
Rajasthan	38.909
Haryana	35.884
Bihar	25.539
Kerala	22.220
West Bengal	8.917
Orissa	5.135
Goa	0.399
Assam	0.350
Himachal Pradesh	0.347
Jammu and Kashmir	0.235
Tripura	0.140
Nagaland	0.017
Meghalaya	0.006
Manipur	0.005
Arunachal Pradesh	NIL
Mizoram	NIL
Sikkim	NIL
UTS	3.246

Source: Annual Report 1990-91, Department of Power, Ministry of Energy, Govt. of India, N. Delhi.

Rural electrification has made energisation of pumpsets possible and as a result of improved irrigation facilities, food production has increased in the country.

Inspite of heavy investment made by the Government and sizeable expansion taken in electrification of villages, most of the villages experience power cut or irregular supply of power specially during the peak period. Regular supply of power is essential for overall economic development of rural areas.

SUMMARY

Rural electrification has become a very important element for socio-economic development in rural areas. It is essential for modernisation of rural areas which provides food, industrial raw material, labour etc. for other sectors of the economy. Rural electrification is very significant for the Indian economy as 80 per cent of its population live in villages and earn their livlihood from agriculture. Rural electrification has made energisation of pumpsets possible, which has resulted in increased agricultural production. It also plays a crucial role in the growth of rural industries. It is not only an important infrastructure and input for the economic development of rural areas but also plays a great role in social transformation before Independence there was no policy for rural electrification in India. After the drought period of 1965 emphasis was laid on energisation of pumpsets to increase agricultural production. As a result rural electrification was given high priority during the Fourth and the Fifth Five Year Plans. By the end of the Seventh Plan, nearly three-fourth of the villages had been electrified, which resulted in energisation of around 80 lakhs electric pumpsets to meet irrigation needs of farmers. Rapid augmentation of underground irrigated facilities resulted in manifold increases in agricultural production. Rural Electrification Corporation was established in 1969 for the promotion and extension of power supply to rural areas and financing of rural electrification. The outlays on rural electrification have increased from Rs. 8 crores during the First Plan to Rs. 1,699 crores in the Sixth Plan. The number of villages electrified has increased from 0.03 lakhs in 1950-51 to 4.78 lakhs in 1990-91, which is an impressive progress during this period. Eight States of Maharashtra, Andhra Pradesh, Gujarat, Himachal Pradesh, Punjab, Haryana and Kerala achieved 100 per cent of rural electrification, while several other states have achieved more than 80 per cent of rural electrification. The number of pumpsets energised increased tremendously from 21,008 in 1950-51 to 89,09,110 in 1990-91. Rural electrification has made energisation of pumpsets possible and as a result of improved irrigation facilities, food production has increased in the country.

CHAPTER - VIII

CONCLUSION

The main problem of power sector in India has been the gap between demand and supply. This gap has been increasing due to increase in the consumption of power. Consumption pattern shows that in the beginning power was mainly consumed by industrial sector and in urban areas, later on with rural electrification, its consumption has increased in rural areas for irrigation purposes, rural based industries and domestic use. This has led to increase in demand for power at a rapid rate outstripping the availability of power. As a result shortages of power in various parts of the country. Power shortage continue to prevail in the country despite increase in installed capacity and improvement in power generation. We have observed in our study that the gap between supply and demand has been widening affecting the regular supply of power. In this chapter an attempt has been made to summarise the study and a few suggestions have also been made.

8.1 SUMMARY OF THE STUDY

Power is the basic input for industrial and agricultural development and for overall economic growth of a country. Power is the most preferred form of energy due to its versatility and convenience both in its use as well as its generation. Power industry in India has developed into one of the most important basic industries of our economy. It is one of the powerful vehicle of economic progress and social changes. In India, modernisation of industries, mechanisation of agriculture and urban progress call for a continuing increase in the availability of electric power.

Though transmission and distribution is an important component of power development programme, it has not been accorded the required priority by the power sector, with the result serious constraints in utilization of available power are being found in many areas. The low level of investment in transmission and distribution has resulted in severe imbalances in system performances compared to realisation of targets in generation. These imbalances resulted largely in poor quality of power supply in addition to higher line losses. It also caused bottlenecks in full utilization of the generated power.

We have observed from the study that hydro power had been the most preferred source of power development in the first three plans which accorded high priority for

River-valley developments. Hydro power development registered substantial increases in these plans (from 559 MW in 1950 to 5907 MW in 1968-69 of total hydro capacity). The decline in the contribution of hydro power to the overall capacity addition commenced in the Fourth Five Year Plan, reached a value of 28.9 per cent at the end of the Seventh Five Year Plan from 46.15 in 1966. The declining trend continues leading to sub-optimal operation. The contribution of hydro power declined considerably during the Sixth Plan and the Seventh Plan creating an imbalance in the hydro thermal mix. Though a judicious and optimal hydro-thermal mix for improved economics of system operation indicates a ratio of 40:60 for the Indian system.

The assessment made by Central Electricity Authority shows that 78 per cent of hydro potential still remains undeveloped in the country despite inherent advantages of hydro electric power plants over thermal and nuclear plants. The share of hydro power has slowed down considerably due to constraints of financial resources, longer gestation period in installing a hydro plant, environmental considerations as well as problems in acquisition of forest land.

Lack of adequate financial resources has been one major constraint in the matter of hydro power development in the country. The Central Electricity Authority was charged with the function of developing the national power policy and co-ordinating the power development particularly in relation to the control and the utilization of national power resources. In accordance of the provisions of the Act, the State Governments established electricity Boards in their respective areas during the period from 1950 to 1967. The State Electricity Boards are entrusted with the general work of promoting power generation, transmission and distribution facilities within their respective states in the most efficient and economic way. Development of power has been given high priority in the plan programmes. The main objective of power development has been to increase power availability and extend power supply to all the regions of the country.

The generation capacity determines the maximum limit of power genration available during a particular period. The total installed capacity in India has increased from 1,712 MW in 1950 to 69,025 MW in 1991-92 registering 9.2 per cent compound annual growth. The gap between hydel and thermal capacities was not very significant till 1965-66. From 1966-67 the gap in electric power generation from thermal and hydel resources started widening. The situation had competely changed in the beginning of the Fourth Five Year Plan with greater emphasis on thermal projects. The total power generation has increased rapidly from 5,107 million units in 1950 to 286,711 million units in 1991-92 recording 11.3 per cent compound annual growth rate. Bulk of electricity generation has taken place from thermal power.

The consumption of power is one of the basic indicators of growth and productivity of national economy.

It has increased in India at a faster rate over the decades. Its consumption has been increasing by various sectors of the economy. The consumption of electric power in agricultural sector has increased from 3.9 per cent in 1950 to 24.97 per cent in 1989-90 and in domestic sector it has gone up from 12.6 per cent in 1950 to 16.12 per cent in 1989-90. Consumption pattern shows that the demand for power is continuously increasing at a rapid rate outstripping the availability of power. This has resulted in continued shortages of power in various parts of the country. Power shortage prevails in the country despite increase in installed capacity. Power shortage hinders the economic growth of modern economy and affect industry, agriculture and household sectors adversely.

During five year plans emphasis has been laid to increase installed capacity and generation to meet the growing demand. During the First Five Year Plan the country's resources were mobilised in such a way that the impetus needed for power industry was available. The First Five Year Plan included a number of multipurpose river valley projects, with hydro electric power generation as on important component. The installed capacity of 1,100 MW was added to total installed capacity during this plan. The Second Five Year Plan was deviced to produce rapid industrialisation, laid emphasis on the power sector. The main aim of the plan was to increase the installed capacity to meet the demand of power. The targetted growth of installed capacity could not be achieved during the plan, due to foreign exchange difficulties and delays in the execution of some projects. The Second Five Year Plan put a greater stress on the hydro electricity. As a result multipurpose projects and a number of single purpose hydro electric projects were taken up.The Third Five Year Plan laid emphasis on infrastructural facilities for industrial development. It gave priority to rural electrification to increae power supply to rural areas for energisation of pumpsets and domestic uses.

During the Third Plan, interconnection between state grid system was recognised to enable interstate transfer of electric power. For the formation of the grid system,the country was divided into five regions each with a Regional Electricity Board. The installed capacity of 4,052 MW was added to total installed capacity during this plan.

The development of power under three Annual plans was also rapid. The significant feature of these plans was initiation of nuclear power development at Tarapur. During these plans massive rural electrification programme had also been taken up.

During the Fourth Five Year Plan, the need for greater participation by the Central Government was realised to increase the power generation programme. Emphasis was also laid on interstate and inter-regional lines to reduce the imbalance between generating capacity and the transmission and distribution facilities. The rural co-operatives and Rural Electrification Corporation were also set up during this plan. The first nuclear power station in the country went into operation during this plan period. Despite increase in installed capacity power shortage was faced during this plan.

The Fifth Five Year Plan gave priority to speed up the construction programme and commissioning of power generation project and also maximising generation from the available capacities. Two central organisations, namely, National Thermal power corporation and National Hydro-electric Power Corporation were set up to increase power generation in the country during this plan. Nuclear power also progressed during this plan. The transmission voltage in commercial transmission of electricity went upto 400 KV in the country for the first time during this plan. The Sixth Five Year Plan gave high priority to increase power supply facilities in the country. The main emphasis of this plan was to improve the functioning of thermal power stations. At the end of the Sixth Plan, a comprehensive renovation and modernisation programme for poorly functioning thermal power plants was approved as a cantrally sponsored scheme. Power shortage was experienced in many parts of the country during this plan due to shortfall in the capacity additions, unsatisfctory performance of the thermal stations and incomplete transmission lines.

The Seventh Five Year Plan laid emphasis on augmentation of power availability in order to achieve the generation target and construction of transmission and distribution facilities, besides, the Seventh Plan also gave importance to the programme of renovation and modernisation, research and development and training in power sector. At the end of the plan 21402 MW of installed capacity was added to the existing capacity. High priority was given to reduce power shortage by improving the performance of the existing power plants in this plan period. The emphasis was also laid on small, micro and mini hydel units to maintain the balanced growth of power in the country.

The main features of the approved power programme during the Eighth plan are induction of additional generating capacity of 31,115 MW, shift away from thermal to hydro electric power, renovation and modernisation of old power plants and strengthening of transmission and distribution system.

Power supply industry is a capital intensive industry and hence, a large chunk of national resources are allocated in every plan to add to the installed generating capacity and to create the complementary transmission and distribution facilities. The investment in power sector has increased from Rs. 260 crores in the First Five Year Plan to Rs. 34,273 crores in the Seventh Five Year Plan indicating a significant growth.

Transmission and distribution are important components of the powr development in a country. With the increase in generation capacity, transmission and distribution networks have also increased through out the country. The construction of transmission projects is also essential in the context of evacuation of power from generating stations to the beneficiary states. With the Central participation in power sector High voltage transmission lines are increasing in circuit kilometers.

There is a wide range of resources from which electric power can be generated. These resources include fossil fuels like coal, gas petroleum products, nuclear materials as well as renewable sources of energy such as biomass, geothermal, hydel and solar source.

Hydro power is an important primary and conventional energy source for generating electricity. Hydro power plants utilize a natural resource which is renewable and have a relatively long life. There is immense potential of energy produced from hydro power in India. The river systemsprovide plenty of scope for large scale hydro development. India is endowed with towering amountain ranges, rolling hills, lofty plateaus and extensive plains criss-crossed by rivers affording scope for hydro generation.

The first hydro electric power plant in India was set up in Darjeeling in 1897. This was followed by many hydro electric power plants during the early part of twentieth century. Inspite of an early start, the progress of hydro powr was very slow and the total hydro installed capacity by the year 1951 was only 570 MW. During the first three five year plans emphasis was laid on hydro powr development as a result, five major multipurpose projects were set up. The important multi-purpose projects under-taken during this period were Bhakra Nangal Project and Chambal Valley project in the North, Hirakund and Damodar Valley in the East and Tungabhadra in the South. Besides, these projects several single purpose hydro electric projects were also taken during the first three five year plan period. At the end of the third plan, the total installed capacity reached upto 5900 MW. The need for central participation in hydro electric development was felt during the Fourth Plan period. The National Hydro Electric Power Corporation was set up during the Fifth Plan to enable greater central participation, particularly in regard to major projects in remote areas, but the emphasis shifted to thermal power projects after the Fifth Plan. This shift in favour of thermal power has been continuous. Towards the end of the

Sixth Five Year Plan the capacities in hydel stood at 11,384 MW and in thermal 16,424 MW. The hydro-thermal mix which was 40:60 during the Fifth Five Year Plan came down to 33.7:66.3 at the end of the Sixth Plan. According to Central Electricity Authority assessment more than 75 per cent of hydro potential still remains unharnessed despite inherent advantages of hydro electric power plants over thermal and nuclear plants.

Lack of adequate financial resources has been one major constraints in the matter of hydro power developments in the country. Since the short term solutions to mitigate the immediate power shortage have been getting priority over long-term solutions, thermal projects having substantially shorter gestation periods have been getting pushed up for early gains, leading to the deferring of benefits from hydro schemes and power development has moved along sub-obtimal course. In India environmental clearances are given to hydro projects, after a lapse of considerable time which has resulted in substantial time and cost over-runs. These delays have been mainly due to various procedural constraints and dealys in necessary studies required to be conducted for making an overall assessment of impact of the concerned power project on the environment. Differences and disputes between reparian states on sharing of water resources have inhibited and delayed hydro-development in some major river systems. In fact Inter-state disputes in the Narmada, the Godavari and the Krishna river basins were partly responsible for Madhya Pradesh, Maharashtra and Andhra Pradesh turning away from hydro after pioneering developments in the Chambal, the Koyna, the sileru and the Tungabhadra Valleys. Most of the undeveloped sites in river systems require Inter-State cooperation. Such co-operation would involve participation in completing investigation and project report preparation, project organisation and management and financing. Besides this, uncertainities in constructing civil works in difficult geological terrains and several administrative and managerial problems associated with specific hydro projects have also been contributing to the slow pace of hydro power development in the country.

Hydro-power is the cheapest among various available sources of power supply because in case of hydel power, the fuel cost component is nil as compared to other conventional options of power supply. Hydro power utilize natural resource which are renewable and the production of power does not consume water. Unlike coal it does not involve transportation of raw materials by rail. Thus the effect of inflation on the raw material and the transport is not reflected on the cost of generation. Hydro-power projects have a relatively longer life and low depreciation, unforseen breakdowns are less frequent and overhaul and maintenance require plan shutdowns of very short duration. Their operation and maintenance costs are low compared to other sources of power generation. Their ability for quick start and stop operation and varrying their output make them eminently suitable for meeting peak loads. Therefore, hydro power needs to be harnessed to the maximum possible units.

Thermal power dominates the Indian power scene as it constitutes over 67 per cent of total installed capacity and contributes about 69.8 per cent of total power generation. It has a maximum share in the total power generation in India. The phenomenal growth of thermal power generation may be due to their low gestation period, flexibility of site selection, ease of augmentation of existing facilities etc. A modern thermal power plant is a highly complex marvel of engineering, built essentially of structural steel.A thermal power station will be able to generate electric power to its rated capacity only, if all its constituent sub units operate cooperatively.

Coal is an important resource for thermal power plants in India. It has been bearing the main burden of power needs of the country. India's coal resources have been assessed at one per cent of the world's total coal reserves. The Energy policy Committees (1980) has assessed that available coal reserves of India would be adequate to last for about hundred years. The main reserves of coal in India are concentrated in West Bengal, Bihar, Assam, Orissa, Madhya Pradesh, Maharashtra and Andhra Pradesh. Coal production in India has increased with the increase in industrial sector and generation of thermal power.

In India the thermal power programme was started in 1889. Thermal power plants were used for urban electrification in the earlier phase of power generation in India. When India became independent, the total thermal installed capacity was nearly 756 MW which has increased to 48,096 MW in 1991-92. There has been three fold increase in thermal installed capacity from 1975-76 to 1991-92. A note-worthy feature of this growth pattern is the quadruple increase in thermal capacity alone as compared to hydel and others. This has brought the thermal share to about 69 per cent in 1990-91 as compared to 54 per cent in 1976-77. The total power generation which was 2998 million units in 1951 increased to 1,73,728 million units in 1989 contributing around 72 per cent in overall electricity generation. the rapid growth of installed capacity made it imperative to adopt larger unit sizes to facilitate quicker capacity addition which provided added advantage of economy of scale and benefit of higher efficiency due to higher steam parameters. It is found that the larger sized thermal stations enjoy greater economy of savings in capital and fuel costs.

The performance of thermal plants can be examined through plant load factor. All India average plant load factor has remained almost constant between 44 to 47 per cent from 1979-80 to 1983-84. It improved since 1984-85, because a number of steps have been taken to achieve optimum utilization of the existing thermal capacity. With the implementation of renovation and modernisation schemes to overhaul the old thermal power units, plant load factor has improved. Plant availability factor has been low due to forced outages and planned outages. Due to excessive outages full generating capacity has not been utilised in thermal plants which results in large scale power disruption. The plant load factor varies between different units. It has been observed in India that larger plants have a better plant load factor than the smaller ones. Therefore, larger sets have substantial savings in capital and fuel costs as well as they contribute to increase in power generation too.

State wise plant load factor shows that Andhra Pradesh, Rajasthan, Tamil nadu, Karnataka, Gujarat, Maharashtra, Madhya Pradesh, Delhi and Uttar pradesh achieved plant load factor higher than all India average (54.4 per cent) in 1991-92. The plant load factor is very low in the states of Haryana, West Bengal, Bihar, Orissa and Assam. The plant load factor in many states continue to remain low due to a number of techno-economic factors.

The thermal power stations in India face the problem of poor coal quality and inadequate supply of coal. The coal available for thermal power plants are generally characterised by high ash and high moisture content. The low calorific value of coal supplies to power plants harm the boilers. Many a time inferior grades of coal create serious problems to the machineries. The demand of coal to thermal power stations has increased tremendously. But the supply of coal to thermal power plants has been falling short of demand. Due to inadequate supply of coal many plants, located away from coal mines have to close down their operation. The problem of inadequate supply of coal is because of the shortage of railway wagons and outdated coal loading and unloading equipments.

The generation in thermal plants is also affected due to unavailability of spare parts andinadequate maintenance. Inadequate operation and poor maintenance lead to an adverse affect on the scientific operation and maintenance of the power stations.

The nuclear power was primarily used for military pruposes. The atomic bombing of Hiroshima and Nagasaki in 1945 was the first use of nuclear power for military purposes. But in the early fifties of the twentieth century there was a talk of 'Atom for peace'. Nuclear energy became a definite source of power generation since 1950's when it was first utilized in the United States. It has gradually become an important source of generating electricity in addition to coal and hydro-sources. At present over 417 nuclear reactors with a total installed power generation capcity of nearly 2,97,000 MW are in operation in twenty six countries and generate more than 16 per cent of the world's electricity.

The economic benefit of nuclear power has been well established in many countries. A study published in 1986 by the OECD Nuclear Energy Agency shows that, in most countries, electricity generation with nuclear power plants is cheaper than with coal fired plants. Several other studies on the economics of electricity production from coal and nuclear sources have shown that excepting for those regions where coal is readily available, nuclear power is substantially cheaper than coal based power. Nuclear power is also considered betteer source of energy over other forms of generating electricity because of its economy in fuel consumption.

The relevance of nuclear power as an important supplementary source to coal and hydro power in India, was realised nearly four decades ago.The coal resources in India are unevenly distributeed with most of it deposits found in the eastern and central parts of the country far away from many of the major load centres. Environmental impact of bearing coal for power generation is a matter of great concern. Taking up of a new power scheme is getting difficult due to concerns of submerging valuable forest areas and problems posed by rehabilitation of relatively large population, within the prevailing constrainsts, hydel and coal will continue to play an important role in the energy scene of India. However, in addition to exploiting all available hydel and coal resources in the country, nuclear power to complement other sources for balanced power development is becoming very important. Among the developing countries in the world, India is in unique position of having achieved significant progress in peaceful utilization of nuclear energy for electric power generation. The Atomic Energy Act was passed in Parliament soon after the country gained independence in 1947. In 1954 the Government had established a Department of Atomic Energy charged with the sole responsibility for all nuclear activities in the country. The installed capacity of nuclear power has increased from 420 MW in 1969-70 to 1565 MW in 1990-91. But its percentage share remained constant at 2 per cent of the total capacity.

The Department of Atomic Energy of the Union Government has drawn up a programme for implementation during 1985-2000 A.D. including opening of new uranium mines and augmentation of fuel fabrication facilities to meet the basic input for nuclear power generation. With currently known reserves an ultimate capacity of 3,50,000 MW could be attained by the second half of the 21st century using heavy water reactors followed by fast breeders. At present only small percentage of India's electric power is generated from nuclear sources.

Nuclear power development has recieved maximum attention from the point of view of safety. Beginning from the mining of uranium to the management of radioactive effluent, safety has been the main concern in the development of nucler power. In India, the safety aspects of the nuclear power plants are carried out during all the stages commencing from site selection to commissioning and also right through the operational life time of the plant. Atomic Energy Regulatory Board reviews the various safety aspects before a station is licensed. At present there are four nuclear power stations in India namely Tarapur Atomic power station, Rajasthan Atomic power station, Madras Atomic power station and Narora Atomic power station, which are producing electricity. Nuclear power will play an important role in electric power generation in the years to come. To a country like India that has the constraints of limited fossil resources and a large population, such a power can definitely yield significant benefits during the coming decades.

By structure of power sector, we actually mean its organisation i.e. how the power sector is being looked after by different bodies involved in generation and distribution of power.

The structure and power industry as we see it today in India has emerged over a period of nearly hundred years. At the beginning of the twentieth century a few private companies were operating small power stations mainly catering to urban loads. Electric power was made available to the public by the beginning of twentieth century, though its generation was minimal. During 1930's few states (provincial) government and princely states expanded their activities not only to meet the urban loads but also to provide the inputs for industry and agriculture. Prominent among them was the former state of Mysore, which built a hydro power station that ushered in an era of Industrialisation in the state.

In 1910 the Indian Electricity Act was passed to govern the grant of licenses for electricity generation and distribution. The main aim of this Act was the issue of licences by the State Governments to the suppliers of electric power. A Central Electricity Board was also set up whose responsibility was to promulgate in the public interest, rules specifying service and safety conditions, as well as the manner in which licensees must make annual report. This Act of 1910 was more concerned with the regulatory and safety aspects of electricity than with the organisational structure of the Industry itself. The organisational structure of power industry has emerged only after the Electricity (supply) Act, 1948 was passed. Though governmental control on power sector started in

1940's when some Municipalities and provisional governments began dealing with this sector, but supply of power was not balanced throughout India.

After Independence the constitution of India put electricity in the concurrent list and it became possible for both the Union Government and State Governments to legislate on the subject. It therefore, came to fall under the control of both the central and the state Governments. In 1948, a new break-through came with the electricity supply Act, which enabled proper control of power. The Act provided the establishment of a new statutory organisation, the Central Electricity Authority and the state Electricity Boards which became the main supplying agencies for power throughout the country. The Electricity (supply) Act 1948 was passed on 10th September 1948. The objective of the Act was to "provide for the rationalisation of the production and supply of electricity, for taking measures conducive to power development". After Independence development and promotion of power came in the hands of the Government of India and private companies except Tata Electric Company, Calcutta and Ahmadabad Electricity Supply companies stopped to play any role in this sector.

The Electricity Act of 1948 laid down that a sound, adequate and uniform national policy should be developed coordinating the activities of planning agencies in relation to control and utilization of national power resources. It was in accordance with this Act, that autonomous electricity boards were set up in all the eighteen states except in some north-east areas and the union territories. These boards were entrusted with the responsibiities of promoting the coordinated development of generation, transmission and distribution of electricity within the state in the most efficient and economical manner. They were required to devote particular attention to power development in areas not being served with electricity by any licensee. The State Electricity Boards are charged with the responsibility of generation, transmission and distribution of power in the most efficient and economical manner with particular reference to those areas which are not for the time being supplied with electricity. State Electricity Boards play a major role in our countr'y power policy. The power supply industry is presently owned and operated by and large by the State Electricity Boards. In the States where they exist they are mainly responsible for supply of power to the ultimate consumers.

The Electricity (supply) Act, 1948 also envisaged creation to Central Electricity Authority under the Central Government with the responsibility to develop a sound, adequate and uniform national power policy and Co-ordinate the activities of the various planning agencies. A statutory organisation, the Central Electricity Authority remained only a part time body till 1974 with the setting up of a Seperate Department of Power, the Central Electricity Authority became a full time body dealing with national power policy planning. The CEA is responsible for formulation of short term and respective plans for power development, techno-economic appraisal of power projects, advise State Governments, Electricity Boards and generating companies on operation and maintenance of the power system in an efficient manner, render consultancy services in different areas of electricity, promotion of research in matters relating to electricity and collection of data on generation, distribution and utilisation of power, study of costs, efficiency losses benefits etc. The Central Electriciy Authority has become an important body in the power structure because it deals with policy planning, supervision, consultancy, coordination and research. Its functions have been increasing over the years and both the

State and Central Governments have used the body to the optimum.

The Damodar Valley corporation (DVC) was estblished in 1948 by the Central Government. It is a joint venture by the Government of India, West Bengal and Bihar. It is a multipurpose project and an autonomous body which is responsible for the integrated development of the Damodar Valley in relation to irrigation, flood control, generation and sale of power. Like DVC, Tungabhadra project is a multipurpose project, set up in 1953 under the Andhra Pradesh State Act. It is responsible for generation of Electricity in the Tungabhadra Dam and the Hampi power station. This power goes to the States of Andhra Pradesh and Karnataka. All policy planning and execution covering generation and distribution of this system is done by the Board. Bhakra-Beas Management Board was established in 1967 under the control of the Central Government, it manages the Bhakra Nangal and Beas projects and transmission system.

Nayvelli lignite Corporation was set up in 1956 under the Companies Act. It is a public sector undertaking. It controls both the open cost lignite mines and its associated thermal power station in Tamil Nadu.

North Eastern Electric Power Corporation was established by the Department of power in 1976 to develop the electric power sector in the backward region of the North-east. This corporation is in the Central sector. Its main functions are the construction, generation, mintenance, transmission, distribution and sale of power in north eastern region.

Under the Atomic Energy Act of 1962, the sole responsibility of nuclear power development for electricity generation is vested with the Central Government. The function of establishing nuclear power plants and their operation is being discharged by the Department of Atomic Energy. With the passage of time the Department has acquired enough power and autonomy to not only lay down policy, but execute it as efficiently as possible. At present it can design, erect, commission and operate atomic power plants. It has developed its own fuel fabricating and heavy water plants and fuel disposal units. At present the Department is operating four atomic power plants including Tarapur, Rajasthan, Kalpakkam and Narora.

In the early sixties the advantage of integration of power systems at regional level and the limitation of state as a spatial unit for power planning and operation was recognised. It was considered necessary to adopt regional approach in power planning and the operation of power systems in order to achieve economies in power supply. To promote such an approach the country was divided into five convenient regions and Regional Electricity Boards were created through Central government resolution in 1964. The Regional Electricity Boards are charged with the responsibility of coordinating the operation of power supply industry in the Northern, Western, Southern and North Eastern regions. This enable the power structure to be more efficient because while planning electric power generation, full advantage could be taken of the resources available in the region as a whole.

Rural electrification has been a priority area in power development in India. As the benefits of electricity supply was realised the State Electricity Boards started electricification of rural as well as urban areas. In the beginning electrification simply meant power for household in rural areas. With the result power generation and power consumption was confined to a small sector. During the mid sixties due to food shortage, the Government of India had provided its policy on rural electrification. New diversification had taken place in the form of pump energisation to increase agricultural production. In 1969, the Rural Electrification corporation (REC) was established as a public sector udertaking. The main objective of this Corporation is to finance rural electrification schemes and promotion of rural electrification cooperatives all over the country.

In 1976 the Electricity (supply) Act, 1948 was amended to provide for establishment of generation companies under the authority of Central Government. The national company namely National Thermal powercorporation (NTPC) was established. The NTPC was given the authority to establish regional thermal power stations and made responsible for bulk transmission from those units to the state power system. The NTPC is given the charge of planning promoting and organising the thermal power sector. The NTPC is supposed to investigate new sites, prepare project reports, construct, operate, generate and maintain transmission and distribution of power generated from thermal units. The NTPC has evolved its own management techniques in engineering, construction, finance, materials etc. It has also been able to install super thermal power projects in various regions within a short period of time. At present the NTPC is carrying out the construction and operation of nine super thermal power projects, four combined cycle gas based projects and two transmission projects with a total approved capacity of 15767 MW and about 20200 circuit Kilometers (ckt kms.) of associated 400/220 KV transmission lines, widely extended all over India.

The total installed capacity of NTPC power Stations increased to 10125 MW in 1991 which constituted about 16 per cent of the total capacity spread all over the country.

The National Hydro Electric Power Corporation(NHPC) was established in 1976 to set up major hydro electric projects on regional and national consideration. The main objective of National Hydro Electric Power Corporation are to plan and organise integrated development of hydro-electric power. The gamut of NHPC activities includes investigation, planning, design, construction, operation and maintenance of hydro electric power projects and Extra High Voltage transmission systems.

The Department of power was created in 1974 by the Ministry of Energy. The Department of power is responsible to parliament for laying down national policy planning for the development and regulation of the power resources in India. The Department is also responsible for national policy planning for regulation and conservation of the country's total power resources. All national responsibility of formulating and promoting power sector is given to this Department. It controls the central autonomous corporated and statutory bodies of the power sector and coordinates the activities of the various agencies within the sector. It coordinates relations between the Centre and States, research and development activities including the coordination and development on non-conventional sources of energy to generate power such as solar and total energy. The Department also looks after the efficient working of thermal units especially in regard to supply of coal. It also manages energy supply in the Union territories and executes central projects. This organisation which heads the power sector is flexible in its attitude This permit it to deal with both long term and short term problems. Since it is the coordinating body it has vast powers. Thus, while the Department is not directly involved in the operation of power plants, it does look after both short-term and long term problems of the power sector which ranges from policy planning to the operation of the plant.

The power Finance corporation was set up in 1986 as public limited company under the administrative control of the Department of power. It was established with the main purpose of providing term finance for power projects.

Power Grid Corporation was incorporated in 1989. It is responsible for carrying out the construction of extra high voltage and high voltage transmission lines, sub-stations, load despatch centres and communication facilities in a coordinated and efficient manner to transfer electric power from central generating stations to load centres, within and across the regions with reliability, safety and economy.

Rural electrification has become a very important element for social and economic improvement in the developing countries. It is essential for modernisation of rural areas, provide food, industrial raw material, labour etc.

The Indian economy is predominantly a rural economy as nearly 80 per cent of the population live in villages and the bulk of the rural population is engaged in agriculture. Therefore, villages are the focal points of development and rural electrification plays an important role in the development of the Indian economy.

Water is the primary need of agriculture, underground water for irrigation is very essential for those areas where rainfall is not sufficient. India has substantial potential of underground water which stile remains to be exploited. Electric power makes it possible to maximise the use of underground water for irrigation. The most economical method of pumping out underground water is with the help of electric pumpsets. During the past few years energisation of a large number of pumpsets through rural electrification has boosted the agricultural production in the country. A study conducted by planning Commission in 1965 revealed that as a consequence of the installation of electric pumpsets on existing irrigation works, the area irrigated increased by 66 per cent for both kharif and rabi crop.

Rural electrification also plays an important role in the growth of rural industries. Electric power reduces labour and fuel cost and increase the productivity. Rural electrification has brought a basic change in the life style of rural masses. It has provided modern amenities of life like light, fan, etc. in villages. Thus, rural electrification is not only an important infrastructure and input for the economic development of the rural areas but also plays a great role in social transformation.

There was no policy for rural electrification in India before independence. As a planned programme, rural electrification was started around fifties in the country. In the early years of planning, electric power for rural areas was treated as a special amenity rather than as an input into agriculture and industry. The progress made in rural electrification in the late 1960's was not satisfactory. India experienced a severe drought period from 1965 to 1967. After the drought emphasis was being laid on energisation of pumpsets to increase agricultural production. During the Fourth Plan, energisation of pumpsets were given high priority. During the Fifth Plan, the rural electrification programme was integrated with the Minimum Needs Programme and a target of covering at least 40 per cent of the rural population in each state was adopted. The Minimum Needs Programme for rural electrification was also given high priority during the Sixth and Seventh Five Year Plan. By the end of the Seventh Five Year Plan, nearly three-fourth of the villages had already been electrified, which resulted in energisation of around 80 lakhs electric pumpsets to meet the irrigation needs of farmers, Rapid augmentation of underground irrigation facilities resulted in manifold increase in agricultural production.

Rural Electrification Corporation (REC) came into existence in July 1969 as a government owned company with the primary objective of promoting extension of power supply to rural areas and financing of rural electrification shcemes throughout the country. It aimed to administer the funds provided as central sector outlay for rural electrification in India,on one hand and on the other provide the needed direction and impetus to the concept of integrated rural development through massive exploitation of ground water resources and promoting rural industries. For improving the quality of rural life and to make village electrification meaningful to rural people, the Rural Electrification Corporation had launched a special drive for promotion of rural households electrification during 1989-90. About 4.30 million rural houshold connections were realised under this special programme till 1991-92.

The Rural Electrification Corporation also plays special attention on standardisation of equipment, materials and construction practices and also on introduction of innovative and cost effective technologies in rural distribution works.

The outlays on rural electrification have increased with more emphasis being laid on it in each successive Five Year Plan. Investment on rural electrification was Rs.8 crores in the First Five Year Plan it had increased to Rs. 2108 crores during the Seventh Five Year plan.

State wise rural electrification shows that electrification programme has been uneven among states and union territories, while some states have achieved cent per cent rural electrification in their respective territories, others lag behind. Eight States of Maharashtra, Andhra Pradesh, Gujarat, Himachal pradesh, Punjab, Haryana and Kerala have achieved 100 per cent rural electrification, several other states have achieved more than 80 per cent of rural electrification. The states of Eastern Region have very low percentage of rural electrification compared to other states of the North Western,Southern and Western States.

Rural Electrification Corporation undertook the task of energisation of pumpsets under a national programme known as 'special project Agriculture' which plays an important role in providing timely crops with the operational control in the hands of farmers. This programme has benefitted the farmers who are affected by monsoon failure. In the wake of droughts, the Rural electrification Corporation has established large number of pumpsets and their energisation to provide electricity to rural areas in times of monsoon failure. The number of energised pumpsets were merely 21,008 in 1950-51, it increased to 89,09,110 in 1990-91. Aggricultural output and potentiality of agro-based industries have increased due to availability of dependable means of irrigation.

Inspite of heavy investment made by the Government and sizeable expansion taken in electrification of villages, most of the villages experience power cut or irregular supply of power specially during the peak period. Regular supply of power is essential for overall economic development of rural areas.

8.2 CONCLUSIONS

Power is an essential requirement for industrial and agricultrural growth in particular, and in improving the quality of life in general has been given due recognition in India since independence. Energy in the form of electric power is essential for self-sufficiency in food production and virtual elimination of dependency on imports of essential commodities and industrial input.

Before independence there were very few and small power stations in India which were owned and operated by private as well as public establishments. The first hydro-electric plant in India was commissioned near Darjeeling in 1897 and the first steam power plant was set up in Calcutta in 1899. These were followed by several hydro-electric plants and thermal power plants mainly for serving the needs of urban population and industrial demand.

Before independence, the power generation and consumption situation was very poor in India, inspite of abundant resources and potential. What little development had taken place was confined to urban and industrial areas like Bombay, Calcutta, Ahmedabad, and Kanpur.

In 1910, Indian Electricity Act was passed to regulate the actions of individual private undertakings. Inspite of this Act, growth of power generation was very slow. In 1938, the National planning Committee of the Congress made a number of recommendations for the growth of electric power generation and consumption. These recommendations remained the guiding force behind the power policy after independence in India. Therefore, progress in this sector has been very impressive in the post independence era. The first step that was taken soon after independence was to intorduce a legislation to restructure the power supply industry to promote and rationalise power development in the country. The constituent (legislative) Assembly passed the Eelctricity *(supply) Act on 10th September 1948 to provide for* rationalisation of production and supply of electricity. This Act provides for the establishment of Central Electricity Authority and organisations in State known as State Electricity Boards.

Since the short term solutions to mitigate the immediate power shortage have been getting priority over long-term solutions, consequently thermal projects having substantially shorter gestation period have been getting pushed up for early gains, leading to the deferring of benefits from hydro schemes and power development have moved along sub-optimal course.

The delays in environment and forest clearance are also responsible for slow growth of hydro power in India. Environmental clearances have been given after a lapse of considerable time which results in substantial time and cost over-runs. These delays have been mainly on account of various procedural coustraints and delays in necessary studies required to be conducted for making an overall assessment of impact of the concerned power project on the environment.

Hydro power projects have been delayed due to differences and disputes between States on sharing of water resources. Inter-State disputes in the Narmada, the Godavari and the krishana river basins were partly responsible for Madhya Pradesh, Maharashtra and Andhra Pradesh turning away from hydro power after pioneering developments in the Chambal, the Koyna, the sileru and the Tungabhadra valleys. The gestation period of hydel project is dependant on several factors viz. geological conditions at site, features of the project and the method of construction etc. Since most of the sites are located in remote areas where infrastructural facilities for transportation and communications are lacking the same is resulting in prolonged period of initial site preparation. Besides this, uncertainities in constructing civil works in difficult geological terrains and several administrative and managerial problems associated with specific hydro projects have also been contributing to the slow pace of hydro power development in the country.

Though thermal power has a maximum share in he total power generation in India as it constitutes over 67 per cent of total installed capacity and contributes over 69.8 per cent of total power generation, but its performance has not been upto the mark due to various reasons such aslow plant load factor in thermal station, high percentage of unforseen outages, inferior quality of coal, unavailability of spare parts, short supply of coal, poor maintenance, outdated design of equipments etc.

Plant load factor, which provides an indication of performance of thermal plants is not satisfactory in Indian thermal power stations. Plant load factor has been low due to ageing of some of the thermal plants, higher incidence of outages, poor quality and inadequate supply of coal non-availability of spares in stock, inadequate maintenance, inadequate training of staff, defective supply of equipments etc. All India average plant load factor has been low as against the plant load factor in National Thermal Power Corporation's plants. Some of the State Electricity Boards such as Haryana, Bihar, Orissa and Assam are operating at plant load factor as low as 30 per cent. It has also been observed that number of outages have been increasing in thermal plants. Due to excessive outages full generating capacity is not utilized in thermal power plants, as a result large scale power disruption takes place. Forced outages have been more than planned outages. Forced outages contributes heavily to the rather gloomy picture of availability of power from thermal station. Coal is the vital input in thermal power stations and the coal as available for thermal power stations is generally characterised by high ash content. The low calorific value of coal supplies to power plants further harm the boilers. The use of inferior quality of coal has been resulting in fast wear and tear of various components and frequent outages leading to lower availability and less output from thermal power stations. Besides proper quality of coal, the problem of adequate quantity of coal to thermal power plants is also increasing. The coal reserves are located far away from load centres, therefore, transportation of bulk quantities of coal to the respective power stations is a serious problem. The Indian Railways is not able. to transport the required amount of coal to the power stations in time due to many constraints like shortage of railway wagons, non availability of rail tracks etc.

The generation of electric power in thermal plants is also affected due to unavailability of spare parts and inadequate maintenance unforced outlays in the take place because most of the State Electricity Boards do not assess the need of spare parts at the time of installation of the plant. Poor maintenance of the plants is another cause of low capacity utilization in thermal plants. Schedule maintenance of the plants have been delayed to maintain the level of power supply, which results in forced outages in the plant and affect machinery adversely.

Another problem of thermal power stations is related to the operation and maintenance which is not upto the mark due to poor technical knowledge of the personnel and lack of cooperation of the workers. Besides this, the practice of frequent transfers of workers from one division to other does not allow them to acquire efficiency in their jobs. All this leads to an adverse effect on the scientific operation and maintenance of the power stations.

The emission of various gaseous products like carbon dioxide, sulphur dioxide, oxides of nitrogen (No_x), etc. and fly ash from thermal power stations create environmental pollution in the country.

India is producing only 2 per cent of electric power from nuclear sources, but radiation hazards and safety aspects associated with nuclear power plants create problems in installing a new nuclear power plant. Safety of reactors is one of the main factors restricting the expnsion of nuclear power. It has recieved maximum public attention especially after the chernoboyl accident in 1986.

Inspite of heavy investment made by the Government and sizeable expansion taken in electrification of villages, most of the villages experience power cut or irregular supply of power specially during the peak period. Regular supply of power is essential for overall economic development of rural areas. It has become all the more important because the farmers have given up the traditional instruments of farming and have switched over to such equipments which are run by the electric power. Many a times they fail to run their pumpsets and machineries due to unavailabiity of power, which adversely affects the agricultural productivity.

It has also been observed that rural electrification has mainly benefitted large and medium farmers while small farmers are not getting full benefit of it due to inadequate credit facilities.

The capital and operating costs of rural electrification have been increasing due to unsatisfactory planning, execution, operation and development of rural electrification systems by State Electricity Boards.

Besides there is a poor management in rural electrification department as they do not have an affective ward and watch system. There are many unauthorised connections in the rural areas which lead to power failure due to heavy load on the line on one hand and on the other it causes loss of revenue to the government.

It has also been observed that State-wise rural electricification programme has been uneven among the States and Union territories, while some states have achieved cent per cent rural electrification in their respective territories, otherslag behind. Electrification of villages has been low in the states of Bihar, Orissa, West Bengal, Tripura, Meghalaya and Manipur. Energisation of pumpsets in rural areas has also been uneven as small number of pumpsets have been energised in Bihar, West Bengal, Orissa and Rajasthan, while Maharashtra, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, karnataka, Uttar Pradesh and Punjab have large number of energised pumpsets.

Many structural changes have taken place in the power sector in India since the beginning of this century.

After Independence the Government of India and State governments have established a number of Corporations and Boards to develop power industry efficiently. But we have observed that these Corporations and Boards have failed to achieve the desired objectives. It may be due to large bureaucratisation and red tapism. Another significant point that we have observed is the lack of co-ordination between these bodies. The elctricity tariff varies from state to state. Most of the State Electricity Boards are having huge losses and they fail to make regular payments to power generating units and therefore, the power plants find it very difficult to run the show.

8.3 SUGGESTIONS

It has been observed in the study that the gap between demand and supply of power has been increasing at a faster rate. In the context of the present power shortage and resource crunch for implementation of new power projects, various measures to manage the supply and demand may help in bridging the existing gap.

The first measure to improve the supply is to get better output from the existing facilities. To increase the supply in a situation of resource constraints optimal output from existing installed capacity is needed. To achieve these, the power generating units which were installed more than a decade back and were based on the outdated technology prevalent at that time, may be made to give better output by utilising the advanced technology available in the field through modificationa and renovation of the equipments. The plant availability factor in power stations is also very low. In this context greater emphasis should be given on training of operation and maintenance personnel. The State Electricity Boards should take all necessary steps to ensure that the statutory requirement of having all the operators trained is fully met.

The demand management consists of shifting system load from peak hours to the off peak and thereby improving to power system load factor. The load management techniques create additional loads during off-peak hours by transfer from peak load to average load hours during the day. This kind of approach will be very beneficial for Indian systems which have power shortage during peak hours and energy surplus during off peak hours. Therefore, it is suggested that various options for reducing the peak demand to the extent feasible should be worked out.

Another option to manage the demand of power is through improvement in end-use efficiency or energy conservation. The energy conservation is seen as an indirect way of increasing the power availability. Analysis of the consumption pattern of electrticity in different categories shows that the consumption of electricity in domestic as well as in the agricultural sector has been constantly increasing. The share of electric power consumption in the industrial sector, however, has declined from 63 per cent in 1950 to 46 per cent in 1989-90. The percentage share of consumption in other sectors have remained fairly constant. The analysis reveals that the major thrust areas for conservation of electricity are -

(i) domestic,

(ii) industrial,

(iii) agricultural sectors.

The Inter-ministerial Working Group on utilisation and conservation of energy set up by the Government has estimated the conservation potential at 25 per cent in the industrial sector and 30 per cent in the agricultural sector. In the case of electricity, the savings were estimated to be equivalent to installation of 5250 MW and 1870 MW in the indusrial and agricultural sectors respectively, pointing a huge potential for energy conservation in these two sectors in the country.

In the present context of increasing costs and endemic power shortage arising from difficulties of augmenting power supply facilities due to diverse reasons, energy conservation may be a solution to the problems of power shortage in India.

It has been observed in the study that transmission and distribution loss is high in the power sector in India. The growth of transmission and distribution system could not keep pace with the growth in generation capacity may be due to low level of investment in transmission and distribution during the five year plans. This has resulted in severe imbalances in the system performance. Therefore, it is proposed that due priority may be given in making adequate investments in transmission and distribution works with a view to reduce the imbalances. It may also be ensured that the outlay earmaked for transmission and distribution is not diverted to other projects.

Analysis of hydro power development depicts that hydro power development was given high priority during the first three five year plans. It registered substantial increase during these plan The decline in the contribution of hydro power to the overall capacity addition commenced in the Fourth Five Year Plan, reached a value of 28 per cent at the end of the Seventh plan. A optimal hydro thermal mix for improved economies of system operation indicates a ratio of 40:60 for the Indian system.

Optimisation studies on long-term power planning show that without proper hydel power back up, the overall cost of meeting the power demand is more costly. Therefore, it is suggested that necessary measures should be taken to improve the hydro-thermal mix during the course of planning.

The operational availability in hydro plans can be improved through planned maintenance as well as renovation and modernisation of a plant.

It has been observed in the study that 66226 MW of potential available for hydro power development still remains unharnassed despite inherent advantages of hydro electric power plants over thermal and nuclear plants. Bulk of the undeveloped potential lies in the northern region. Therefore, it is suggested that unharanessed hydro projects should be developed in those areas which are away from coal resources like Northern Region, and has plenty of scope for hydro development.

Since the short term solutions to mitigate the immediate power shortage have been getting priority over long-term solutions, thermal power projects having substantially shorter gestation periods have been getting pushed up for early gains, leading to the deferring of benefits from hydro schemes and power development has moved along sub-optimal course. A decision is required to strike a balance between short term and long term solutions so that the power development could move towards optimal course. Accelerated hydro power development would be the corner stone of improvement in productivity of power sector in the long run. In this context, it is suggested that Government of India may advise the Power Finance Corporation limited to provide necessary funding for the development of attractive hydro projects, which are languishing since long.

The share of hydro power is also declining as environmental and forest clearances are given after a lapse of considerable time which has resulted in substantial time and cost over-runs. To reduce time and cost over-run due to delayed environment and forest clearance procedures, procedural bottlenecks must be identified and clearance process must be streamlined. Often it is found that the Ministry of Environment and Forest seek information and details from the project authorities in a piecemeal manner leading to delay in the clearance of the projects. It is suggested that the Ministry of Environment and Forest should seek additional information and details in one go so that the delays could be avoided. Inter-state differences and disputes over sharing of water resources are delaying many important hydro-electric projects. Settlement of these differences would have to be followed by active co-operation between state in which the potential sites are located for rapid development of the hydro power potential in the country. Inter state co-operation would involve participation in completing investigation, project report preparation, project organisation and management and financing.

To reduce gestation period of hydel projects the Government of India may advise State Governments central/ state organisations responsible for developing hydro electric projects to take up site development including site clearance, roads formation and provision of telecommunication links as soon as the schemes are techno-economically cleared by Central Electricity

Authority, to speed up the construction activities. The project implementing authorities may take up these works as advance action without awaiting final sanction by the government.

Accelerated hydro power development is very essential because it is the cheapest among various available sources of power and utilize natural resource. Hydro projects have a relatively longer life and low depreciation. They have the unique advantage of increasing the capacity of peaking manifold by having pumped storage schemes. Therefore, hydro power should be harnessed to the maximum possible limit.

It has been observed from the study that performance of thermal plants in the country is not satisfactory as plant load factor is not upto the mark. Plant load factor in many states continue to remain low and trail far behind the capacity. It has been very low in the states of Haryana, West Bengal, Bihar, Orissa, and Assam. All India plant load factor has been low as compared to plant load factor in National Thermal Power Corporation Units. All India average plant load factor in 1989-90 was 65.5 per cent as against 68 per cent of National Thermal Power Corporation plants. The plant load factor of thermal power plants can be improved by reducing the periods for planned shut-down of the unit for thorough maintenance work through proper organisation and coordination. Further improvement in the performance of the thermal power stations may also take place by maintaining high efficiency of operation and high degree of availability of the units. For increasing efficiency of operation of units it may be necessary that the units operate at or near the designed maximum output. Adequate maintenance and operational standards may also be of great importance for obtaining best efficiency. World Bank Report on India's Power Sector Efficiency Review (1989) has also observed that 10 to 15 per cent capacity gain can be economically obtained by efficiency imporvement.

To improve the perofrmance of thermal plants the availability of the plants should be increased. It has been found out that pulverised boilers have been reponsible for unavailability of the plants. Therefore, improvement in the design of boilers may increase availability factor. Modifications in basic design and materials of the equipments may also improve the availability of the plant. The availability factor would also increase if forced outages may be brought down to the minimum by following proper maintenance practices. The availability of the required spares at right time may also reduce waiting time for spares during the period of outages.

It has also been noticed that some of the thermal units would complete their expected life by 1994-95, while many units of 60 MW have completed their life and majority of the 100 to 150 MW units have been in service for more than 15 years. So they require major overhauling. As the units go on ageing, their performance declines. Therefore, thermal power plants need major renovation and modernisation schemes. Renovation and modernisation of all the aged units may increase the plant load factor of thermal plants. It is also suggested that whenever the plants under go renovation, efforts should be made to introduce modern sub-systems which were not available earlier at the time of installation of the units, to improve their performance.

We have observed in our study that the main problem of thermal power plants is the quality and supply of coal. In order to overcome the problem of poor coal quality, the process of coal beneficiation is suggested. But the coal beneficiation process results in production of considerable waste of combustible matter in the form of rejects. In order to solve this problem of quality of coal without jeopardising the coal conservation policy, simple beneficiation process are being suggested. It has also been observed that inferior grades of coal are being supplied to the thermal power plants creating serious problems to boilers, which are basically designed to use different and superior grade of coal. The supply of coal to power stations should be in requisite quantity and also of good calorific value according to the boiler design so that the cost of power generation may not increase further.

Air pollution is one of the grey areas with coal based power generation. The main air pollutants generated are particulate matters, sulphur dioxide, oxides of carbon and nitrogen. Various measures may minimise their impact on the ecology. The improved design of electostatic precipitators may result in controlling fly ash emission to very low level. Besides, various new technologies available may also help in controlling environmental pollution of thermal plants.

In view of the abundant availability of nuclear fuels in the country, it would be worthwhile to lay stress on the installation of nuclear power stations in future, specially in the areas which are far away from coal belts so as to cut down on transportation cost of coal and ease congestion on railways. However, appropriate safety measures in regard to setting up of neuclear power sttions may have to be strictly followed.

It has been observed in the study that supply of power is not regular in rural areas due to lack of close integration in many States between the planning of rural electrification and the rest of the distribution network. Therefore, it is suggested that the integration of generation, transmission & distribution planning should comprise the rural electrification system also, and power cut should be brought to minimum to enhance the agricultural productivity. Besides irregular supply of power, there are sharp fluctuations in voltage and power load factor due to poor planning, execution and maintenance of the distribution system. To reduce fluctuation and improve load factor in rural areas, State Electricity Boards should take necessary steps for proper planning, execution operation and development of rural electrification systems. The Boards should also check the illegal connections to avoid revenue losses. It has also been observed that rural electrification has been uneven among the states and Union territories. For the balanced development of the rural areas backward and undeveloped states and Union territories should also be electrified. Further the flow of benefits of rural electrification should not be confined to large and rich farmers but small and poor farmers may also get fair share of rural electrification and for this easy loan facilities should be provided to them.

It has also been observed that State Electricity Boards are mainly responsible for generation, transmission and distribution of power in the country. They constitute more than 80 per cent of the countrys power generation and transmission and almost entire distribution of power, yet their performance is very dismal. The State Electricity Boards are critisized for their inability to operate power generating and distribution systems efficiently. Almost all the State Electricity Boards are running at losses. The causes of inefficiencies in State Electricity Boards may be because the Boards have not yet adopted the modern management system. The same old bureaucratic style of functioning still prevails in the State Electricity boards. The maintenance of the generating plants, transmission and distribution is gloomy. Research and Development activities are in a low state in the State Electricity Boards. Therefore, it is suggested that modern management system should be introduced in State Electricity Boards. Maintenance should be improved through skilled personnel and importance should be given to proper training facilities. In order to improve the perofrmance of the power industry and increase in installed capacity it has been suggested by the Rajadhyaksha committee that we have to choose the ways which minimise investment, maximise operational efficiency, major structural, organisational, procedural, financial, technical changes will need to be made with immediate effect in the power industry.

It also suggested that for the healthy growth of the power sector and to formulate agreed policies and programmes, there should be close and constant interaction and better coordination among different organisationof power industry.

It is high time that private sector participation in the power sector may be given due importance. The public sector alone will not be able to raise sufficient resources to invest on new power generation projects for meeting the rapidly growing demand for electric power in the coming years. Therefore, considerable emphasis may be given to private investments for power development, Private sector investment could bridge the shortfall in the resources for additional power capacity.

(a)

TABLE - A. 2.1

INSTALLED POWER CAPACITY: 1950-1991-92

(MW)

Year	Hydel	Thermal	Nuclear	Total	% Variation
1950	559	1153	-	1713	11.4
1951	575	1260	-	1835	7.2
1952	715	1347	-	2062	12.4
1953	731	1574	-	2305	11.8
1954	793	1701	-	2494	8.2
1955	939	1756	-	2695	8.1
1956	1061	1825	-	2886	7.1
1957-58	1214	2009	-	3223	11.7
1958-59	1362	2150	-	3512	9.0
1959-60	1530	2343	-	3873	10.3
1960-61	1917	2736	-	4653	20.1
1961-62	2419	2800	-	5219	12.2
1962-63	2936	2865	-	5801	11.2
1963-64	3167	3409	-	6576	13.4
1964-65	3389	4008	-	7397	12.5
1965-66	4124	4903	-	9027	22.0
1966-67	4757	5335	-	10092	11.8
1967-68	5487	6396	-	11883	17.7
1968-69	5907	7050	-	12957	9.0
1969-70	6135	7547	420	14102	8.8
1970-71	6383	7906	420	14709	4.3
1971-72	6612	8222	420	15254	3.7
1972-73	6785	8876	620	16281	6.1
1973-74	6965	9058	640	16663	2.3
1974-75	7529	10148	640	18317	9.9
1975-76	8464	11013	640	20117	9.8
1976-77	9025	11804	640	21469	6.7
1977-78	10020	13008	640	23668	10.2
1978-79	10833	15207	640	26680	12.7
1979-80	11384	16424	640	28448	6.6
1980-81	11791	17563	860	30214	6.2
1981-82	12173	19312	860	32345	7.1
1982-83	13056	21447	860	35363	9.3
1983-84	13856	24388	1095	39339	11.2
1984-85	14460	27030	1095	42585	8.3
1985-86	15472	29967	1330	46769	9.8
1986-87	16196	31740	1330	49266	5.3
1987-88	17265	35560	1330	54155	9.9
1988-89	17798	39677	1565	59040	9.0
1989-90	18308	43763	1565	63636	7.1
1990-91	18754	45768	1565	66087	3.9

Compound annual rate of growth

1950-51 & 1960-61	13.1	9.1	-	10.1
1960-61 & 1970-71	12.8	11.2	-	12.2
1970-71 & 1980-81	6.3	8.3	7.4	7.5
1980-81 & 1990-91	4.7	9.9	-	8.1
1950-92	8.8	9.3	-	9.2

Source: Centre for Monitoring Indian Economy, May, 1992, 1993.

TABBE - A. 2.2

POWER GENERATION: 1950 TO 1991-92

(MU)

Year	Hydel	Thermal	Nuclear	Total
1950	2520	2587	-	5107
1951	2860	2998	-	5858
1952	2799	3321	-	6120
1953	2914	3783	-	6697
1954	3237	4285	-	7522
1955	3742	4850	-	8592
1956	4295	5367	-	9662
1957-58	5072	6297	-	11369
1958-59	5848	7146	-	12994
1959-60	7027	8006	-	15033
1960-61	7837	9100	-	16937
1961-62	9814	9856	-	19670
1962-63	11805	10560	-	22365
1963-64	13957	12861	-	26818
1964-65	14799	14764	-	27563
1965-66	15225	17765	-	32990
1966-67	16734	19642	-	36376
1967-68	18658	22537	-	41195
1968-69	20723	26711	-	47434
1969-70	23046	27064	1339	51989
1970-71	25248	28162	2417	55827
1971-72	28024	31712	1189	60925
1972-73	27196	36217	1133	64546
1973-74	28972	35321	2396	66689
1974-74	27285	40109	2206	70190
1975-76	33302	43303	2626	79231
1976-77	34836	50245	3252	88333
1977-78	38007	51091	2272	91369
1978-79	47159	52594	2770	102523
1979-80	45478	56273	2876	104627
1980-81	46542	61301	3001	110844
1981-82	49565	69515	3021	122101
1982-83	48373	79868	2022	130263
1983-84	49954	86677	3546	140177
1984-85	53785	98770	4078	156633
1985-86	50933	114119	4885	170037
1986-87	53764	128818	5023	187605
1987-88	47396	149464	4034	201894
1988-89	57793	157510	5822	221125
1989-90	61996	178522	4623	245141
1990-91	71535	186452	6244	264231
Compound annual rate of growth				
1950-51 & 1960-61	12.0	13.4	-	12.7
1960-61 & 1970-71	12.4	12.0	-	12.7
1970-71 & 1980-81	6.3	8.9	2.2	7.1
1980-81 & 1990-91	4.2	-	-	9.1
1950-92	8.2	11.2	-	10.2

Source: Centre for Monitering India Economy, May 1992, 1993.

(c)

TABLE - 2.3

CONSUMPTION PATTERN IN DIFFERENT CATAGORIES

Energy Sales (GWH)

Year 1	Total 2	Domestic 3	Commercial 4	Industrial 5	Traction 6	Agriculture 7	Others 8
1950	4156.66 (100)	524.59 (12.6)	308.75 (7.5)	2603.81 (62.6)	308.41 (7.4)	161.68 (3.9)	249.42 (6.0)
1951	4793.34 (100)	594.99 (12.4)	331.54 (6.9)	3054.67 (63.7)	329.60 (6.9)	203.04 (4.3)	279.50 (5.8)
1952	5005.68 (100)	68.88 (12.6)	336.63 (6.7)	3206.52 (6.40)	324.75 (6.5)	215.18 (4.3)	293.72 (5.9)
1953	5597.08 (100)	690.52 (12.3)	399.10 (7.1)	3613.22 (64.6)	358.32 (6.4)	214.12 (3.8)	321.80 (5.8)
1954	6252.50 (100)	759.16 (12.1)	446.15 (7.1)	4075.97 (65.2)	378.41 (6.1)	231.39 (3.7)	361.42 (5.8)
1955	7111.01 (100)	850.43 (12.0)	514.43 (7.2)	4698.30 (66.0)	403.31 (5.7)	254.79 (3.6)	389.75 (5.5)
1956-57	7959.34 (100)	934.11 (11.7)	545.84 (6.8)	5323.43 (66.9)	404.93 (5.10	316.18 (4.0)	434.85 (5.5)
1957-58	9345.22 (100)	1093.63 (11.7)	609.81 (6.5)	6166.80 (66.0)	423.29 (4.5)	544.64 (6.0)	507.05 (5.4)
1958-59	10718.61 (100)	1238.03 (11.5)	682.81 (6.3)	7224.05 (67.50	441.56 (4.1)	583.48 (5.5)	548.68 (5.1)
1959-60	12406.94 (100)	1378.54 (11.1)	766.17 (6.2)	8455.52 (68.2)	440.60 (3.6)	753.95 (6.1)	612.16 (4.8)

Contd'...

1	2	3	4	5	6	7	8
1960-61	13840.64 (100)	1492.29 (10.7)	847.74 (6.10	9584.32 (69.4)	453.93 (3.3)	832.93 (6.0)	629.43 (4.5)
1961-62	16448.29 (100)	1698.08 (10.3)	934.09 (5.7)	11545.60 (70.2)	5184.76 (3.6)	991.14 (6.0)	695.22 (4.2)
1962-63	18679.02 (100)	1917.85 (10.3)	1048.62 (5.6)	13109.81 (70.2)	723.84 (3.9)	1103.52 (5.9)	775.38 (4.1)
1963-64	21793.98 (100)	2062.41 (9.7)	1179.72 (5.5)	15841.84 (73.5)	755.17 (2.2)	1153.17 (5.4)	801.26 (3.7)
1964-65	24219.27 (100)	2246.21 (9.2)	1427.48 (5.9)	17378.58 (71.8)	898.33 (3.7)	1396.69 (5.8)	871.98 (3.6)
1965-66	26734.94 (100)	2355.15 (8.8)	1650.06 (6.2)	18875.87 (70.6)	1057.29 (4.0)	1891.84 (7.1)	904.73 (3.3)
1966-67	29127.64 (100)	2626.72 (9.0)	1819.62 (6.2)	20390.80 (70.0)	1180.22 (4.1)	2106.50 (7.2)	1003.78 (3.50
1967-68	32686.87 (100)	2927.97 (8.9)	1750.19 (5.4)	22852.24 (69.9)	1301.66 (4.0)	2585.25 (7.9)	1269.56 (3.9)
1968-69	37352.35 (100)	3184.19 (8.5)	2125.74 (5.7)	25891.23 (69.9)	1246.58 (3.3)	3465.44 (9.3)	1439.07 (3.9)
1969-70	41061.70 (100)	3491.00 (8.6)	2333.33 (5.7)	28378.66 (69.1)	1448.32 (3.5)	3774.11 (9.2)	1636.28 (3.9)
1970-71	43724.16 (100)	3839.76 (8.8)	2572.66 (5.9)	29579.10 (67.6)	1364.57 (3.2)	4470.23 (10.2)	1897.84 (4.3)

Contd'...

1	2	3	4	5	6	7	8
1991-72	47063.20 (100)	4107.46 (8.7)	2952.78 (6.3)	31637.18 (67.2)	1632.69 (3.5)	5005.62 (10.6)	1737.47 (3.7)
1972-73	49088.06 (100)	4309.01 (8.8)	2782.19 (5.7)	32244.21 (65.7)	1830.57 (3.7)	5918.10 (12.0)	2003.98 (4.1)
1973-74	50246.38 (100)	4644.55 (9.2)	2987.52 (6.0)	32481.38 (64.6)	1530.76 (3.0)	6310.21 (12.6)	2291.96 (4.6)
1974-75	52631.64 (100)	5272.79 (9.8)	3081.57 (5.9)	32690.28 (62.1)	1531.17 (2.9)	7762.73 (14.7)	2393.10 (4.6)
1975-76	60245.81 (100)	5821.35 (9.66)	3506.76 (582)	37568.12 (62.36)	1855.32 (3.08)	8721.06 (14.48)	2773.20 (4.7)
1976-77	60608.97 (100)	6336.56 (9.91)	4141.92 (6.22)	41605.63 (62.47)	2167.72 (3.25)	9620.63 (14.44)	2763.11 (4.11)
1977-78	69255.03 (100)	6821.31 (9.85)	4427.59 (6.41)	42635.20 (61.57)	2296.21 (3.32)	10107.36 (14.59)	2966.76 (4.28)
1978-79	77292.82 (100)	7575.66 (9.80)	4330.58 (5.60)	47727.70 (61.75)	2185.58 (2.03)	12027.85 (15.56)	3445.45 (4.46)
1979-80	78083.62 (100)	8402.23 (1076)	4656.58 (5.95)	45955.48 (98.86)	2301.15 (2.95)	13452.00 (17.23)	3316.18 (4.25)
1980-81	82367.18 (100)	9246.43 (11.23)	4681.84 (5.68)	48069.35 (58.36)	2265.91 (2.75)	14489.03 (17.59)	3614.62 (4.59)
1981-82	90245.33 (100)	10439.62 (11.57)	5194.41 (5.76)	53063.79 (58.80)	2504.72 (2.78)	15201.16 (16.84)	3041.63 (4.25)

(e)

Contd'...

1	2	3	4	5	6	7	8
1982-83	95588.57 (100)	12091.63 (12.65)	5846.25 (6.12)	52967.36 (55.41)	2632.60 (2.75)	17816.84 (18.64)	4233.89 (4.43)
1983-84	102344.49 (100)	13234.51 (12.93)	6560.95 (6.41)	57094.47 (55.79)	2709.86 (2.65)	18233.63 (17.81)	4511.07 (4.41)
1984-85	114067.94 (100)	15505.72 (13.59)	6937.39 (6.08)	63019.33 (55.25)	2879.75 (2.52)	20960.44 (18.38)	4765.31 (4.18)
1985-86	122999.34 (100)	17257.83 (14.08)	7290.10 (5.93)	66980.06 (54.46)	(3182.14) (2.91)	23421.97 (19.04)	4967.24 (4.03)
1986-87	135952.08 (100)	19323.13 (14.21)	7772.07 (7.72)	70296.87 (51.71)	3229.41 (2.37)	29443.96 (21.60)	9886.64 (4.33)
1987-88	455612.82 (100)	22119.81 (15.19)	8840.81 (6.07)	69180.10 (47.51)	3616.32 (2.48)	35266.55 (24.22)	6579.23 (4.53)
1988-89	160196.43 (100)	247660.67 (15.46)	9915.17 (6.19)	75411.64 (47.08)	3772.26 (2.35)	38878.37 (24.27)	7451.32 (4.65)
1989-90	174817.57 (100)	28173.93 (16.12)	10227.20 (5.85)	80878.10 (46.26)	4150.38 (2.37)	43643.01 (24.97)	7744.95 (4.43)

(f)

BIBLIOGRAPHY

Arokiaswamy, S.S.N. : Can Electricity Boards be economically viable while fulfilling social obligations?, Indian Journal of Power & River Valley Development Annual Review (1985).

Arokiaswamy; S.S.N. : Problems for meeting Country's Power needs, Indian Journal of Power & River Valley Development, May (1988).

Aron, Sunita : UPSEB is bankcrupt, The Hindustan Times, New Delhi, 26th Sept., (1989).

Boyd, James : Nuclear Energy and Alternatives: Ballnger Publishing Co. Cambridge, (1978).

Bami, S.P. : Power Development; Pitheads Stations Lift hopes, The Hindu Survey of Indian Industry, Madras (1987).

Bhasin; J.K. : Power Perspective for Nineties, Main Stream, New Delhi, 26th Aug., (1989).

Bami, S.P. : NTPC'S role in the Development of Power in India, India Journal of Power & River Valley Development (1989).

Chetty, Somanna.B. : Electricity Distribution - Operation and maintenance. Indian Journal of Power & River Valley Development, Sept. (1976).

Chakravarti; N. : Biggest Power Belt in making, The Hindu Survey of Indian Industry *Madras*, (1987).

Chand, Bahadur : Power Development - The Issues and Options, Indian Journal of Power and River Valley Development, Annual Review (1987).

Chatterjee, Santanu : Financial Management in Private electricity supply companies, Indian Journal of Power and River Valley Development, Dec. (1990).

Desai, A.Ashok : The Indian Electric Power System Economic and Political Weekly Vol.XXII No. 41 (1987).

Dua, L.G. : Rural Electrification in Inda - need for updating technology, Indian Journal of Power River Valley Development, Annual Review (1987).

Dhaul, S.Laxmi : Managing the Demand for Power, The Financial Express, New Delhi, 28th Oct. (1990).

Govil, K.K. : Problems in Thermal Power Development, India Journal of power and River Valley Development May, (1978).

Gujaral, S.T. : Capital Structure of Electricity Boards in India, Indian Journal of Power and River Valley Development, July, (1980).

Guru, D.D. and Ahsan Qamar : Energy and Economic Development, Amar Prakashan, Delhi (1987).

Golkani, M.W. : Great Strides in Power Development, The Economic Times, New Delhi 5th Oct. (1988).

Jain, L.C. : Towards National Power grid, Indian Journal of Power and River Valley Development, March (1984).

Kochar, S.B. & : Rural Electrification in India, Indian Journal of Power and River Valley Development May, (1978).

Krishnan, R. : Problems of Power and Coal Industry Yojna, Vol. 26, Jan (1982).

Keshava, P.G. : A Review of the theory of Electricity Princing, The Indian Economic Journal, Vol. 34 Oct-Dec, (1986).

Kumar, Rajendra. : Social Imposts In Thermal Power Generation, Irrigation and Power Journal, Oct. (1987).

Kulkarni, A.V. : Electricity, The Financial Express New Delhi, 31st Aug. (1989).

Krishnan, R. : Power Projects - Early decision needed, The Hindu Survey of Indian Industry Madras, (1990).

Kati, L.S. : Nuclear Power Generation in India a status Report, Indian Journal of Power and River Valley Development, Dec. (1990).

Lal Arjun : Financial Working of Electricity, Boards Indian Journal of Power and River Valley Development Aug. (1979).

Munasingh, M. : The Economics of Power System Reliability and Planning: Theory and case study, John Hopkins University.

Nigam, S.P. : The Hydro Power Scenario, Indian Journal of Power and River Valley Development, Dec. (1983).

Nandini, Durgesh. : UPSEB - A Study of Financial Performance, Economic Times 8th Dec. (1989).

Narayan, R.K. : Power Development in India, Indian Journal of Power and River Valley Development, Dec. (1989).

Natrajan B. & Natrajan, B. : Power Sector: Short Term Options, Mainstream, New Delhi, 26th Aug. (1989).

Natrajan, B. : Load Management Options for Electric Utilities in India, Indian Journal of Power and River Valley Development, Dec. (1990).

Pachauri, K.R. : Economic issues in Planning for Electrical Energy, Indian Journal of Power and River Valley Development, May, (1978).

Puttaswamy, L.A. : Present day Problems of Interconnected Power Systems in India, Indian Journal of Power and River Valley Development, March (1984).

Ramanna, Raja : Inevitability of Atomic Energy in India's Power Programme, Energy Policy for India, ed. R.K. Pachauri, Macmillan India, (1980).

Roy, S.N. : Major Thrust on Quick Capacity Additions, The Hindu Survey of Indian Industry, (1982).

Rao, C.V.J. : Modernisation of Purchasing in Electricity Boards - A Necessity, Indian Journal of Power and River Valley Development, May,(1984).

Ramanna, R. : Nuclear Power is the Safest and most economic form of producing electricity, Indian Journal of Power and River Valley Development, March, (1987).

Rajagopal, S. : Unfolding Power Scenario, The Hindu Survey of Indian Industry, Madras, (1988).

Rajgopal, S. : Need for a effective power Systems and Load Management, The Hindustan Times, 9th June, (1989).

Rajgopal, S. : "Eighth Plan Thrust Areas," Mainstream, New Delhi, 26th Aug. (1989).

Rao, N.T. : Electric Power in India, Shakti Vishwas, Lucknow.

Sethna, N.Homi. : India's Atomic Energy Programme Past and Future, Indian Journal of Power and River Valley Development, Jan. (1980).

Setha, N.H. : Indian Experience in Nuclear Power Generation, Indian and Foreign Review, New Delhi Vol. 20, Dec. (1982).

Shah, K.P. : NTPC: Marches Ahead, Bhagirath, New Delhi Vol 30, April. (1983).

Sethna, N. Homi : Technology and Economics of Nuclear Power Development in India, Indian Journal of Power and River Valley Development, May (1982).

Sengupta, M. : Energy and Power Policies in India, Sultan Chand and Sons, New Delhi, (1985).

Srinivasan, R.M. : Nuclear Power Generation in India - A Status Report, Indian Journal of Power and River Valley Development Oct. (1987).

Survey, John. : Electric Power Plant In India Economic and Political Weekly Vol.XXIII, No. 8, Feb. (1988).

Suri, L.R. & Mukherjee. : Central Power Generation - Uniform Tariff, The Economics Times, New Delhi, 2nd March (1989).

Singh Joga : Scale Economies in the Indian Thermal Electricity Industry, Indian Journal of Power and River Valley Development, July, (1989).

Sharma K.A. : Fossil Fuel Resources and Prospect of Themal Power in India, Indian Journal of Power and River Valley Development, April (1991).

Taylor, C. : India: Economic Issues in Power Sector, World bank Country Study, Washington, (1979).

Turvey Ralph & Dannis Anderson : Electricity economics, The Press, Cambridge.

Updhyay, K.S. : State Electricity Boards in India: An Introspection, Indian Journal of Power and River Valley Development, Aug. (1982).

Venkatraman, K. : Power Development in India, Wiley Eastern Pvt. Ltd., New Delhi (1972).

Verma, B.L. : Analysis of Generation Cost of Electricity in State Electricity Boards in India, Indian Journal of Power and River Valley Development, Oct-Nov. (1985).

Verma, B.L. : A Contrasting Pattern of capital Structure in SEBs-Need of Restructuring, (1986).

Verma, J.V.C. : Hydro Power Development in India, Indian Journal of Power and River Valley Development, April-May (1992).

REPORTS AND SURVEYS

Annual Report of Rural Electrification Corporation.

Annual Reports of National Hydro Power Corporation.

Annual Reports of National Thermal Power Corporation.

Annual Reports of Dept. of Power, Ministry of Energy.

Report of the Committee on Power (1980) Ministry of Energy, Dept. of Power.

Economic Survey, Ministry of Finance.

Electric Power Survey of India, Central Electricity Authority.

Planning Commission's Reports and Five Year Plans.